SUPPLEMENT

TO THE THIRD EDITION OF THE

ENCYCLOPÆDIA BRITANNICA;

OR, A

DICTIONARY

OF

ARTS, SCIENCES,

AND

MISCELLANEOUS LITERATURE.

IN TWO VOLUMES.

Illustrated with Fifty Copperplates.

By GEORGE GLEIG, LL.D. F.R.S. Edin.

NON IGNORO, QUÆ BONA SINT, FIERI MELIORA POSSE DOCTRINA, ET QUÆ NON OPTIMA, ALIQUO MODO ACUI TAMEN, ET CORRIGI POSSE.——*Cicero.*

VOL. II.

THE SECOND EDITION, WITH IMPROVEMENTS.

Edinburgh:
PRINTED FOR THOMSON BONAR, PARLIAMENT-SQUARE;
BY *JOHN BROWN*, ANCHOR CLOSE, EDINBURGH.

1803.

[Entered in Stationers Hall.]

ADVERTISEMENT.

It would ill become me to difmifs thefe Volumes from my hands without acknowledging that, from many of the moft valuable difquifitions which they contain, I can claim no other merit than that of having ufhered them into the world.

Those who have read, and who underftand, the articles in the Encyclopædia Britannica, which were furnifhed by Profeffor Robifon of Edinburgh, can hardly need to be informed, that to the fame eminent philofopher I am indebted for the valuable articles Arch, Astronomy, Carpentry, Centre, Dynamics, Electricity, Impulsion, Involution *and* Evolution *of Curves*, Machinery, Magnetism, Mechanics, Percussion, Piano-*Forte*, *Centre of* Position, Temperament *in Mufic*, Thunder, *Mufical* Trumpet, Tschirnhaus, and Watchwork, in this Supplement. Of a friend and co-adjutor, whofe reputation is fo well eftablifhed as Dr Robifon's, I am proud to fay, that, while I looked up to him, during the progrefs of this Work, as to my mafter in mathematical and phyfical fcience, I found him ever ready to fupport, with all his abilities, thofe great principles of religion, morality, and focial order, which I felt it my own duty to maintain.

To Thomas Thomfon, M. D. of Edinburgh, a man of like principles, I am indebted for the beautiful articles Chemistry, Mineralogy, and *Vegetable*, *Animal*, and *Dyeing* Substances; of which it is needlefs for me to fay any thing, fince the Public feems to be fully fatisfied that they prove their author eminently qualified to teach the fcience of Chemiftry.

The account of the French Revolution, and of the wars which it has occafioned, has been continued in this Supplement by the fame Gentlemen by whom that account was begun in the Encyclopædia; and, owing to the caufe affigned in the article, probably with the fame merits and the fame defects.

My thanks are due to Dr William Wright for his continued kindnefs in communicating much curious botanical information: and to Mr Profeffor Playfair of the univerfity of Edinburgh, for lending his affiftance, occafionally, in the mathematical department; and for writing one beautiful article in that fcience, which is noticed as his in the order of the alphabet.

In compiling this Supplement, I have made very liberal ufe of the moft refpectable literary and fcientific journals, both foreign and domeftic; of all the late accounts of travels and voyages of difcovery, which have obtained, or feem indeed to deferve, the regard of the Public; of different and oppofite works on the French revolution, and what are emphatically called *French principles;* and even of the moft approved Dictionaries, fcientific and biographical. From no Dictionary, however, have I taken, without acknowledgment, any articles, except fuch as are floating everywhere on the furface of fcience, and are the property, therefore, of no living author.

After

After all my labour and induftry, which, whatever be thought of my other merits, I am confcious have been great, no man can be more fenfible than myfelf, that the Encyclopædia Britannica, even with the addition of this Supplement, is ftill imperfect. It would continue to be fo, were another Supplement added to this by the moft learned and laborious man on earth; for perfection feems to be incompatible with the nature of works conftructed on fuch a plan, and embracing fuch a variety of fubjects.

No candid reader will fuppofe that, by expreffing myfelf thus, I mean to cenfure the plan of the Encyclopædia Britannica in particular; for, to the general excellence of that plan I have elfewhere borne my teftimony, which I have yet feen no reafon to retract. Experience has indeed led me to think, that it is fufceptible of fuch improvements as would enable the principal Editor to carry the work *nearer* to perfection, even with lefs trouble to himfelf; but the purchafers of the third edition and this Supplement need not regret the want of thofe improvements, for they are fuch as few would difcern, who have not paid the fame attention that I have done to dictionaries of arts, fciences, and literature.

Before I take leave of the reader, I muft account for the omiffion of one or two articles (chiefly biographical) which I had given him reafon to expect in thefe volumes. It was my intention at firft to introduce into the Supplement articles on every fubject which had been admitted into the Encyclopædia itfelf; and hence in the firft fupplementary volume will be found biographical fketches of men whofe characters, though in fome refpects remarkable, have very little connection with fcience, arts, or literature. From this part of the original plan I was foon obliged to deviate. So many applications were made to me to infert accounts of perfons who, whatever may have been their private virtues, were never heard of in the republic of letters, that I was under the neceffity of excluding from the fecond volume the lives of *all* fuch as had not either been themfelves eminent in literature, or in fome liberal art or fcience, or been confpicuous as the *patrons* of fcience, arts, and literature, in others. Hence the omiffion of the life referred to from Aubigne in the firft volume, and of one or two others to which references are made in the fame way. The life of Mr James Hay Beattie of Aberdeen, whofe originality of genius, ardent love of virtue, and early and extenfive attainments in fcience and literature, raife him almoft to the eminence of Barretier, of whom we have fo pathetic an account from the pen of Johnfon, I omitted with regret; but I thought not myfelf authorized to publifh what his father had then only diftributed among a few particular friends. For the omiffion of the life of Soame Jenyns I can make no apology: it was the confequence of forgetfulnefs.

For the *errors* of thefe two volumes, whether typographical or of a nature more important, I have perhaps no occafion to folicit greater indulgence than will be voluntarily extended to me by a generous Public. Some errors I have corrected in this fecond impreffion, and fome deficiencies I have fupplied; but I was reftrained by thofe who are now Proprietors of the Work from making any *addition* to the firft volume, or any confiderable *alteration* in the firft part of the fecond. Hence the different conclufions which the reader will obferve in the articles Galvanism and Torpedo, refpecting the nature of the *Galvanic* power. Of thefe articles, the former was furnifhed by a friend, whofe name I am not at liberty to publifh; but whofe reafonings appeared to me too worthy of attention to be either omitted or abridged, though they lead to a conclufion which facts more recently afcertained feem to fet afide. Thefe facts I felt it my duty to ftate to the public; and, under the title Torpedo, I have been enabled to ftate them with the precifion and regularity of arrangement which characterife the writings of Dr Thomfon.

SUPPLEMENT

TO THE

ENCYCLOPÆDIA BRITANNICA.

INCREMENT, is the fmall increafe of a variable quantity. Newton, in his Treatife on Fluxions, calls thefe by the name *Moments;* and obferves, that they are proportional to the velocity or rate of increafe of the flowing or variable quantities in an indefinitely fmall time. He denotes them by fubjoining a cypher o to the flowing quantity whofe moment or increment it is; thus, xo the moment of x. In the doctrine of Increments, by Dr Brooke Taylor and Mr Emerfon, they are denoted by points below the variable quantities; as $\underset{.}{x}$. Some have alfo denoted them by accents underneath the letter, as $\underset{'}{x}$; but it is now more ufual to exprefs them by accents over the fame letter, as x'.

METHOD OF INCREMENTS, a branch of Analytics, in which a calculus is founded on the properties of the fucceffive values of variable quantities, and their differences or increments.

The inventor of the method of increments was the learned Dr Taylor, who, in the year 1715, publifhed a treatife upon it; and afterwards gave fome farther account and explication of it in the Philof. Tranf. as applied to the finding of the fums of feries. And another ingenious and eafy treatife on the fame, was publifhed by Mr Emerfon, in the year 1763. The method is nearly allied to Newton's Doctrine of Fluxions, and arifes out of it. Alfo the Differential method of Mr Stirling, which he applies to the fummation and interpolation of feries, is of the fame nature as the method of increments, but not fo general and extenfive.

INDETERMINATE PROBLEM. See ALGEBRA, Part I. Chap. VI. *Encycl.*

Diophantus was the firft writer on indeterminate problems, which, after the publication of his work in 1621 by Bachet, employed much of the time of the moft celebrated mathematicians in Europe. Afterwards fuch problems were neglected as ufelefs, till the public attention was again drawn to them by Euler and La Grange. The example of fuch men was followed by Mr John Leflie, a very eminent and felf-taught mathematician; who, in the fecond volume of the Tranfactions of the Royal Society of Edinburgh, has publifhed an ingenious paper on indeterminate problems, refolving them by a new and general principle. "The doctrine of indeterminate equations (fays Mr Leflie) has been feldom treated in a form equally fyftematic with the other parts of algebra. The folutions commonly given are devoid of uniformity, and often require a variety of affumptions. The object of this paper is to refolve the complicated expreffions which we obtain in the folotion of indeterminate problems, into fimple equations, and to do fo, without framing a number of affumptions, by help of a fingle principle, which, though extremely fimple, admits of a very extenfive application.

"Let $A \times B$ be any compound quantity equal to another, $C \times D$, and let m be any rational number affumed at pleafure; it is manifeft that, taking equimultiples, $A \times m B = C \times m D$. If, therefore, we fuppofe that $A = m D$, it muft follow that $m B = C$, or $B = \frac{C}{m}$. Thus two equations of a lower dimenfion are obtained. If thefe be capable of farther decompofition, we may affume the multiples n and p, and form four equations ftill more fimple. By the repeated application of this principle, an higher equation, admitting of divifors, will be refolved into thofe of the firft order, the number of which will be one greater than that of the multiples affumed."

For example, refuming the problem at firft given, viz. to find two rational numbers, the difference of the fquares of which fhall be a given number. Let the given number be the product of a and b; then by hypothefis, $x^2 - y^2 = ab$; but thefe compound quantities admit of an eafy refolution, for $\overline{x+y} \times \overline{x-y} = a \times b$. If, therefore, we fuppofe $x + y = ma$, we fhall obtain $x - y = \frac{b}{m}$; where m is arbitrary, and if rational, x and y muft alfo be rational. Hence the refolution of thefe two equations gives the values of x and y, the numbers fought, in terms of m; viz.
$x = \frac{m^2 a + b}{2m}$, and $y = \frac{m^2 a - b}{2m}$.

INDUCTION, in logic, is that procefs of the underftanding by which, from a number of *particular* truths perceived by fimple apprehenfion, and diligently compared together, we infer another truth, which is always *general* and fometimes *univerfal.* It is perhaps needlefs to obferve, that in the procefs of induction the truths to be compared muft be of the fame kind, or relate to objects having a fimilar nature; for the mereft tyro

tyro in ſcience knows that phyſical truths cannot be compared with moral truths, nor the truths of pure mathematics with either.

That the method of induction is a juſt logic has been ſufficiently evinced elſewhere (ſee Logic, Part III. chap. V. and Philosophy, n° 73—78, *Encycl.*), and is now indeed generally admitted. It is even admitted by Britiſh philoſophers to be the only method of reaſoning by which any progreſs can be made in the phyſical ſcinces; for the laws of Nature can be diſcovered only by accurate experiments, and by carefully noting the agreements and the differences, however minute, which are thus found among the phenomena apparently ſimilar. It is not, however, commonly ſaid that *induction* is the method of reaſoning employed by the mathematicians; and the writer of this article long thought, with others, that in pure geometry the reaſoning is ſtrictly *ſyllogiſtical*. Mature reflection, however, has led him to doubt, with Dr Reid*, the truth of the generally received opinion, to doubt even whether by categorical ſyllogiſms any thing whatever can be proved.

* Appendix to Vol. III. of *Sketches of the Hiſtory of Man.*

To the idolaters of Ariſtotle we are perfectly aware that this will appear an extravagant paradox; but to the votaries of truth, we do not deſpair of making it very evident, that for ſuch doubts there is ſome foundation.

We are led into this diſquiſition to counteract, in ſome degree, what we think the pernicious tendency of the philoſophy of Kant, which attempts have been lately made to introduce into this country. Of this philoſophy we ſhall endeavour to give ſomething like a diſtinct view in the proper place. It is ſufficient to obſerve here, that it reſts upon the hypotheſis, that "we are in poſſeſſion of certain notions *à priori*, which are abſolutely *independent of all experience*, although the *objects of experience* correſpond with them; and which are diſtinguiſhed by *neceſſity* and ſtrict *univerſality*." Theſe innate and univerſal notions, Kant conſiders as a ſet of *categories*, from which is to be deduced all ſuch knowledge as deſerves the name of ſcience; and he talks, of courſe, or at leaſt his Engliſh tranſlators repreſent him talking, with great contempt, of inductive reaſoning, and ſubſtituting ſyllogiſtic demonſtration in its ſtead.

As his categories are not familiar to our readers, we ſhall, in this place, examine ſyllogiſms connected with the categories of Ariſtotle, which are at leaſt more intelligible than thoſe of Kant, and which, being likewiſe general notions, muſt, in argument, be managed in the ſame way. Now the fundamental axiom upon which every categorical ſyllogiſm reſts, is the well known propoſition, which affirms, that "whatever may be predicated of a whole *genus*, may be predicated of every *ſpecies* and of every *individual* comprehended under that genus." This is indeed an undoubted truth; but it cannot conſtitute a foundation for reaſoning from the *genus* to the *ſpecies* or the *individual;* becauſe we cannot poſſibly know what can be predicated of the *genus* till we know what can be predicated of all the *individuals* ranged under it. Indeed it is only by aſcertaining, through the medium of induction, what can be predicated, and what not, of a number of individuals, that we come to form ſuch notions as thoſe of *genera* and *ſpecies;* and therefore, in a ſyllogiſm ſtrictly categorical, the propoſitions which conſtitute the *premiſſes*, and are taken for granted, are thoſe alone which are capable of proof; whilſt the concluſion, which the logician pretends to demonſtrate, muſt be evident to intuition or experience, otherwiſe the premiſſes could not be known to be true. The analyſis of a few ſyllogiſms will make this apparent to every reader.

Dr Wallis, who, to an intimate acquaintance with the Ariſtotelian logic, added much mathematical and phyſical knowledge, gives the following ſyllogiſm as a perfect example of this mode of reaſoning in the firſt figure, to which it is known that all the other figures may be reduced:—

> *Omne animal* eſt *ſenſu præditum.*
> *Socrates* eſt *animal.* Ergo
> *Socrates* eſt *ſenſu præditus.*

Here the propoſition to be demonſtrated is, that Socrates is endowed with ſenſe; and the propoſitions aſſumed as ſelf-evident truths, upon which the demonſtration is to be built, are, that "every animal is endowed with ſenſe;" and that "Socrates is an animal." But how comes the demonſtrator to know that "every animal is endowed with ſenſe?" To this queſtion we are not aware of any anſwer which can be given, except this, that mankind have agreed to call every being, which they perceive to be endowed with ſenſe, an *animal.* Let this then be ſuppoſed the true anſwer: The next queſtion to be put to the demonſtrator is, How he comes to know that *Socrates* is an *animal?* If we have anſwered the former queſtion properly, or, in other words, if it be eſſential to this genus of beings to be endowed with ſenſe, it is obvious that he can know that Socrates is an *animal* only by perceiving him to be *endowed with ſenſe;* and therefore, in this ſyllogiſm, the propoſition to be proved is the very firſt of the three of which the truth is perceived; and it is perceived intuitively, and not inferred from others by a proceſs of reaſoning.

Though there are ten categories and five predicables, there are but two kinds of categorical propoſitions; viz. Thoſe in which the property or accident is predicated of the ſubſtance to which it belongs, and thoſe in which the *genus* is predicated of the *ſpecies* or *individual.* Of the former kind is the propoſition pretended to be proved by the ſyllogiſm which we have conſidered; of the latter, is that which is proved by the following:

> Quicquid ſenſu præditum, eſt animal.
> Socrates eſt ſenſu præditus. Ergo
> Socrates eſt animal.

That this is a categorical ſyllogiſm, legitimate in mode and figure, will be denied by no man who is not an abſolute ſtranger to the very firſt principles of the Ariſtotelian logic; but it requires little attention indeed to perceive that it proves nothing. The impoſition of names is a thing ſo perfectly arbitrary, that the being, or claſs of beings, which in Latin and Engliſh is called *animal*, is with equal propriety in Greek called ζωον, and in Hebrew נפש. To a native of Greece, therefore, and to an ancient Hebrew, the major propoſition of this ſyllogiſm would have been wholly unintelligible; but had either of thoſe perſons been told by a man of known veracity, and acquainted with the Latin tongue, that every thing endowed with ſenſe was, by the Romans, called *animal*, he would then have underſtood the propoſition, admitted its truth without heſitation, and have henceforth

henceforth known that Socrates and Mofes, and every thing elfe which he perceived to be endowed with fenfe, would at Rome be called *animal*. This knowledge, however, would not have refted upon demonftrative reafoning of any kind, but upon the credibility of his informer, and the intuitive evidence of his own fenfes.

It will perhaps be faid, that the two fyllogifms which we have examined are improper examples, becaufe the truth to be proved by the former is felf-evident, whilft that which is meant to be eftablifhed by the latter is merely verbal, and therefore arbitrary. But the following is liable to neither of thefe objections:

All animals are *mortal*.
Man is *an animal*; therefore
Man is *mortal*.

Here it would be proper to afk the demonftrator, Upon what grounds he fo confidently pronounces all animals to be mortal? The propofition is fo far from expreffing a felf-evident truth, that, previous to the entrance of fin and death into the world, the firft man had furely no conception of mortality. He acquired the notion, however, by experience, when he faw the animals die in fucceffion around him; and when he obferved that no animal with which he was acquainted, not even his own fon, efcaped death, he would conclude that all animals, without exception, are mortal. This conclufion, however, could not be built upon fyllogiftic reafoning, nor yet upon intuition, but partly upon experience and partly on analogy. As far as his experience went, the proof, by induction, of the mortality of all animals was complete; but there are many animals in the ocean, and perhaps on the earth, which he never faw, and of whofe mortality therefore he could affirm nothing but from analogy, *i. e.* from concluding, as the conftitution of the human mind compels us to conclude, that Nature is uniform throughout the univerfe, and that fimilar caufes, whether known or unknown, will, in fimilar circumftances, produce, at all times, fimilar effects. It is to be obferved of this fyllogifm, as of the firft which we have confidered, that the propofition, which it pretends to demonftrate, is one of thofe truths known by experience, from which, by the procefs of induction, we infer the major of the premiffes to be true; and that therefore the reafoning, if reafoning it can be called, runs in a circle.

Yet by a concatenation of fyllogifms have logicians pretended that a long feries of important truths may be difcovered and demonftrated; and even Wallis himfelf feems to think, that this is the inftrument by which the mathematicians have deduced, from a few poftulates, accurate definitions, and undeniable axioms, all the truths of their demonftrative fcience. Let us try the truth of this opinion, by analyfing fome of Euclid's demonftrations.

In the fhort article Principle (*Encycl.*), it has been fhewn, that all our *firft* truths are *particular*, and that it is by applying to them the rules of induction that we form general truths or axioms—even the axioms of pure geometry. As this fcience treats not of real external things, but merely of *ideas* or *conceptions*, the creatures of our minds, it is obvious, that its definitions may be perfectly accurate, the induction by which its axioms are formed complete, and therefore the axioms themfelves *univerfal* propofitions. The ufe of thefe axioms is merely to fhorten the different proceffes of geometrical reafoning, and not, as has fometimes been abfurdly fuppofed, to be made the *parents* or *caufes* of *particular* truths. No truth, whether general or particular, can, in any fenfe of the word, be the caufe of another truth. If it were not true that all individual figures, of whatever form, comprehending a portion of fpace equal to a portion comprehended by any other individual figure, whether of the fame form with fome of them, or of a form different from them all, are equal to one another, it would not be true that "things in *general*, which are equal to the fame thing, or that magnitudes which coincide, or exactly fill the fame fpace," are refpectively equal to one another; and therefore the firft and eight of Euclid's axioms would be falfe. So far are thefe axioms, or general truths, from being the parents of particular truths, that, as conceived by us, they may, with greater propriety, be termed their *offspring*. They are indeed nothing more than general expreffions, comprehending all particular truths of the fame kind. When a mathematical propofition therefore is enounced, if the terms, of which it is compofed, or the figures, of which a certain relation is predicated, can be brought together and immediately compared, no demonftration is neceffary to point out its truth or falfehood. It is indeed intuitively perceived to be either comprehended under, or contrary to fome known *axiom* of the fcience; but it has the evidence of truth or falfehood in itfelf, and not in *confequence* of that axiom. When the figures or fymbols cannot be immediately compared together, it is then, and only then, that recourfe is had to demonftration; which proceeds, not in a feries of fyllogifms, but by a procefs of ideal menfuration or induction. A figure or fymbol is conceived, which may be compared with each of the principal figures or fymbols, or, if that cannot be, with one of them, and then another, which may be compared with it, till through a feries of well known intermediate relations, a comparifon is made between the terms of the original propofition, of which the truth or falfehood is then perceived.

Thus, in the 47th propofition of the firft book of Euclid's Elements, the author propofes to demonftrate the equality between the fquare of the hypothenufe of a right angled triangle, and the fum of the fquares defcribed on the other two fides; but he does not proceed in the way of categorical fyllogifms, by raifing his demonftration on fome univerfal truth relating to the *genus* of *fquares*. On the contrary, he proceeds to *meafure* the three fquares, of which he has affirmed a certain relation; but as they cannot be immediately compared together, he directs the largeft of them to be divided into two parallelograms, according to a rule which he had formerly afcertained to be juft; and as thefe parallelograms can, as little as the fquare of which they are the conftituent parts, be compared with the fquares of the other two fides of the triangle, he thinks of fome intermediate figure which may be applied as a common meafure to the fquares and the parallelograms. Accordingly having before found that a parallelogram, or fquare, is exactly double of a triangle ftanding on the fame bafe and between the fame parallels with it, he conftructs triangles upon the fame bafe, and between the fame parallels with his parallelograms, and the fquares of the fides containing the right angle of the original triangle; and finding, by a procefs formerly fhewn to be juft, that the triangles on the bases of the parallelograms are precisely equal to the triangles on the bases of the squares, he perceives at once that the two parallelograms, of which the largest square is composed, must be equal to the sum of the two lesser squares; and the truth of the proposition is demonstrated.

In the course of this demonstration, there is not so much as one truth *inferred* from another by *syllogism*, but all are perceived in succession by a series of simple apprehensions. Euclid, indeed, after finding the triangle constructed on the base of one of the parallelograms to be equal to the triangle constructed on the base of one of the squares, introduces an *axiom*, and says, "but the doubles of equals are equal to one another; *therefore* the parallelogram is equal to the square" But if from this mode of expression any man conceive the axiom or universal truth to be the *cause* of the truth more particular, or suppose that the *latter* could not be apprehended without a *previous* knowledge of the former, he is a stranger to the nature of evidence, and to the process of *generalization*, by which axioms are formed.

If we examine the problems of this ancient geometrician, we shall find that the truth of them is proved by the very same means which he makes use of to point out the truth of his theorems. Thus, the first problem of his immortal work is, "to describe an equilateral triangle on a given finite straight line; and not only is this to be done, but the method by which it is done must be such as can be shewn to be incontrovertibly just. The sides of a triangle, however, cannot be applied to each other so as to be immediately compared; for they are conceived to be immoveable among themselves. A common measure, therefore, or something equivalent to a common measure, must be found, by which the triangle may be constructed, and the equality of its three sides afterwards evinced; and this equivalent Euclid finds in the *circle*.

By contemplating the properties of the circle, it was easy to perceive that all its *radii* must be equal to one another. He therefore directs two circles to be described from the opposite extremities of the given finite straight line, so as that it may be the radius of each of them; and from the point in which the circles intersect one another, he orders lines to be drawn to the extreme points of the given line, affirming that these three lines constitute an equilateral triangle. To convince his reader of the truth of this affirmation, he has only to put him in mind, that from the properties of the circle, the lines which he has drawn must be each equal to the given line, and of course all the three equal to one another; and this mutual equality is perceived by simple apprehension, and not inferred by syllogistic reasoning. Euclid, indeed, by introducing into the demonstration his first axiom, gives to it the form of a syllogism: but that syllogism proves nothing; for if the equality of the three sides of the triangle were not intuitively perceived in their position and the properties of the circle, the first axiom would itself be a falsehood. So true it is that categorical syllogisms have no place in geometrical reasoning; which is as strictly experimental and inductive as the reasoning employed in the various branches of physics.

But if this be so, how come the truths of pure geometry to be necessary, so that the contrary of any one of them is clearly perceived to be impossible; whilst physical truths are all contingent, so that there is not one of them of which the direct contrary may not easily be conceived?

That there is not one physical truth, of which the contrary may not be conceived, is not perhaps so certain as has generally been imagined; but admitting the fact to be as it has commonly been stated, the apparent difference between this class of truths and those of pure geometry, may be easily accounted for, without supposing that the former rests upon a kind of evidence totally different from that which supports the fabric of the latter.

The objects of pure geometry, as we have already observed, are the creatures of our own minds, which contain in them nothing concealed from our view. As the mathematician treats them merely as measurable quantities, he knows, with the utmost precision, upon what particular properties the relation affirmed to subsist between any two or more of them must absolutely depend; and he cannot possibly entertain a doubt but it will be found to have place among all quantities having the same properties, because it depends upon them, and upon them alone. His process of induction, therefore, by a series of ideal measurements, is always complete, and exhausts the subject; but in physical inquiries the case is widely different. The subjects which employ the physical inquirer are not his own ideas, and their various relations, but the properties, powers, and relations of the bodies which compose the universe; and of those bodies he knows neither the substance, internal structure, nor all the qualities: so that he can very seldom discover with certainty upon what particular property or properties the phenomena of the corporeal world, or the relations which subsist among different bodies, depend. He expects, indeed, with confidence, not inferior to that with which he admits a mathematical demonstration, that any corporeal phenomenon, which he has observed in certain circumstances, will be always observed in circumstances exactly similar; but the misfortune is, that he can very seldom be ascertained of this similarity. He does not know any one piece of matter *as it is in itself*; he cannot separate its various properties; and of course cannot attribute to any one property the effects or apparent effects which proceed exclusively from it. Indeed, the properties of bodies are so closely interwoven, that by human means they cannot be completely separated; and hence the most cautious investigator is apt to attribute to some one or two properties, an event which in reality results perhaps from many. (See PHILOSOPHY and PHYSICS, *Encycl.*) This the geometrician never does. He knows perfectly that the relation of equality which subsists between the three angles of a plain triangle and two right angles, depends not upon the size of the triangles, the matter of which they are conceived to be made, the particular place which they occupy in the universe, or upon any one circumstance whatever besides their triangularity, and the angles of their corrolets being exactly right angles; and it is upon this power of discrimination which we have in the conceptions of pure geometry, and have not in the objects of physics, that the truths of the one science are perceived to be necessary, while those

Inertia, Inflammation.

those of the other appear to be contingent; though the mode of demonstration is the same in both, or at least equally removed from categorical syllogisms.

INERTIA. See DYNAMICS and IMPULSION in this *Supplement*.

INFLAMMATION has been sufficiently explained in the *Encyclopædia*, and in the article CHEMISTRY in this *Supplement;* but it cannot be improper, in this place, to give an account of some remarkable

Spontaneous INFLAMMATIONS, which, as different substances are liable to them, have been, and may again be, the cause of many and great misfortunes.

The spontaneous inflammation of essential oils, and that of some fat oils, when mixed with nitrous acid, are well known to philosophers; so also is that of powdered charcoal with the same acid (lately discovered by M. Proust), and those of phosphorus, of pyrophorus, and of fulminating gold. These substances are generally to be found only in the laboratories of chemists, who are perfectly well acquainted with the precautions which it is necessary to take to prevent the unhappy accidents which may be occasioned by them.

The burning of a store-house of sails, which happened at Brest in the year 1757, was caused by the spontaneous inflammation of some oiled cloths, which, after having been painted on one side, and dried in the sun, were stowed away while yet warm; as was shewn by subsequent experiments*.

* See *Memoires de l'Academie de Paris*, 1760.

Vegetables boiled in oil or fat, and left to themselves, after having been pressed, inflame in the open air. This inflammation always takes place when the vegetables retain a certain degree of humidity; if they are first thoroughly dried, they are reduced to ashes, without the appearance of flame. We owe the observation of these facts to MM. Saladin and Carette†.

† *Journal de Physique*, 1784.

The heaps of linen rags which are thrown together in paper manufactories, the preparation of which is hastened by means of fermentation, often take fire, if not carefully attended to.

The spontaneous inflammation of hay has been known for many centuries; by its means houses, barns, &c. have been often reduced to ashes. When the hay is laid up damp, the inflammation often happens; for the fermentation is then very great. This accident very seldom occurs to the first hay (according to the observation of M. de Bomare), but is much more common to the second; and if, through inattention, a piece of iron should be left in a stalk of hay in fermentation, the inflammation of that stalk is almost a certain consequence. Corn heaped up has also sometimes produced inflammations of this nature. Vanieri, in his *Prædium Rusticum*, says,

> *Quæ vero (gramina) nondum satis insolata recondens*
> *Imprudens, subitis pariunt incendia flammis.*

Dung also, under certain circumstances, inflames spontaneously.

In a paper, published in the *Repertory of Arts and Manufactories*, by the Rev. William Tooke, F. R. S. &c. we have the following remarkable instances of spontaneous inflammation. "A person of the name of Rüde, an apothecary at Bautzen, had prepared a pyrophorus from rye-bran and alum. Not long after he had made the discovery, there broke out, in the next village of Nauslitz, a great fire, which did much mischief, and was said to have been occasioned by the treating of a sick cow in the cow-house. Mr Rüde knew, that the countrymen were used to lay an application of parched rye-bran to their cattle for curing the thick neck; he knew also that alum and rye-bran, by a proper process, yielded a pyrophorus; and now he wished to try whether parched rye-bran alone would have the same effect. Accordingly, he roasted a quantity of rye-bran by the fire, till it had acquired the colour of roasted coffee. This roasted bran he wrapped up in a linen cloth; in the space of a few minutes there arose a strong smoke through the cloth, accompanied by a smell of burning. Not long afterwards the rag grew as black as tinder, and the bran, now become hot, fell through it on the ground in little balls. Mr Rüde repeated the experiment at various times, and always with the same result. Who now will any longer doubt, that the frequency of fires in cow-houses, which in those parts are mostly wooden buildings, may not be occasioned by this common practice, of binding roasted bran about the necks of the cattle? The fire, after consuming the cattle and the shed, communicates itself to the adjoining buildings; great damage ensues; and the ignorant look for the cause in wilful and malicious firing, consequently in a capital crime."

The same author informs us, that in the spring of the year 1780, a fire was discovered on board a Russian frigate lying in the road of Cronstadt; which, if it had not been timely extinguished, would have endangered the whole fleet. After the severest scrutiny, no cause of the fire was to be found; and the matter was forced to remain without explanation, but with strong surmises of some wicked incendiary being at the bottom of it. In the month of August, in the same year, a fire broke out at the hemp-magazine at St Petersburgh, by which several hundred thousand poods* of hemp and flax were consumed. The walls of the magazine were of brick, the floors of stone, and the rafters and covering of iron; it stands alone on an island in the Neva, on which, as well as on board the ships lying in the Neva, no fire is permitted. In St Petersburgh, in the same year, a fire was discovered in the vaulted shop of a furrier. In these shops, which are all vaults, neither fire nor candle is allowed, and the doors of them are all of iron. At length the probable cause was found to be, that the furrier, the evening before the fire, had got a roll of new cere-cloth (much in use here for covering tables, counters, &c. being easily wiped and kept clean), and had left it in his vault, where it was found almost consumed.

* A pood consists of 40 pounds Russ, or 36 English.

In the night between the 20th and 21st of April 1781, a fire was seen on board the frigate Maria, which lay at anchor, with several other ships, in the road off the island of Cronstadt; the fire was, however, soon extinguished; and, by the severest examination, little or nothing could be extorted concerning the manner in which it had arisen. The garrison was threatened with a scrutiny that should cost them dear; and while they were in this cruel state of suspence, an order came from the sovereign, which quieted their minds, and gave rise to some very satisfactory experiments.

It having been found, upon juridical examination, as well as private inquiry, that in the ship's cabin, when the smoke appeared, there lay a bundle of matting, containing Russian lamp-black prepared from fir-soot, moistened with hemp oil varnish, which was perceived

to

Inflammation. to have ſparks of fire in it at the time of the extinction, the Ruſſian admiralty gave orders to make various experiments, in order to ſee whether a mixture of hemp-oil varniſh and the forementioned Ruſſian black, folded up in a mat and bound together, would kindle of itſelf.

They ſhook 40 pounds of fir-wood ſoot into a tub, and poured about 35 pounds of hemp-oil varniſh upon it; this they let ſtand for an hour, after which they poured off the oil. The remaining mixture they now wrapped up in a mat, and the bundle was laid cloſe to the cabin, where the midſhipmen had their birth. To avoid all ſuſpicion of treachery, two officers ſealed both the mat and the door with their own ſeals, and ſtationed a watch of four ſea-officers, to take notice of all that paſſed the whole night through; and as ſoon as any ſmoke ſhould appear, immediately to give information to the commandant of the port.

The experiment was made the 26th of April, about 11 o'clock A. M. in preſence of all the officers named in the commiſſion. Early on the following day, about ſix o'clock A. M. a ſmoke appeared, of which the chief commandant was immediately informed by an officer: he came with all poſſible ſpeed, and through a ſmall hole in the door ſaw the mat ſmoking. Without opening the door, he diſpatched a meſſenger to the members of the commiſſion; but as the ſmoke became ſtronger, and fire began to appear, the chief commandant found it neceſſary, without waiting for the members of the commiſſion, to break the ſeals and open the door. No ſooner was the air thus admitted, than the mat began to burn with greater force, and preſently it burſt into a flame.

The Ruſſian admiralty, being now fully convinced of the ſelf-enkindling property of this compoſition, tranſmitted their experiment to the Imperial Academy of Sciences; who appointed Mr Georgi, a very learned and able adjunct of the academy, to make farther experiments on the ſubject. Previous to the relation of theſe experiments, it is neceſſary to obſerve, that the Ruſſian fir-black is three or four times more heavy, thick, and unctuous, than that kind of painters black which the Germans call *kien-rahm*. The former is gathered at Ochta, near St Peterſburgh, at Moſco, at Archangel, and other places, in little wooden huts, from reſinous fir-wood, and the unctuous bark of birch, by means of an apparatus uncommonly ſimple, conſiſting of pots without bottoms ſet one upon the other; and is ſold very cheap. The famous fine German *kien-rahm* is called in Ruſſia *Holland's black*. In what follows, when raw oil is ſpoken of, it is to be underſtood of linſeed-oil or hemp oil; but moſt commonly the latter. The varniſh is made of five pounds of hemp-oil boiled with two ounces and a half of minium. For wrapping up the compoſition, Mr Georgi made uſe of coarſe hemp-linen, and always ſingle, never double. The impregnations and commixtures were made in a large wooden bowl, in which they ſtood open till they were wrapped up in linen.

Three pounds of Ruſſian fir-black were ſlowly impregnated with five pounds of hemp-oil varniſh; and when the mixture had ſtood open five hours, it was bound up in linen. By this proceſs it became clotted; but ſome of the black remained dry. When the bundle had lain ſixteen hours in a cheſt, it was obſerved to emit a very nauſeous, and rather putrid, ſmell, not quite unlike that of boiling oil. Some parts of it became warm, and ſteamed much; this ſteam was watery, and by no means inflammable. Eighteen hours after the mixture was wrapped up, one place became brown, emitted ſmoke, and directly afterwards glowing fire appeared. The ſame thing happened in a ſecond and a third place, though other places were ſcarcely warm. The fire crept ſlowly around, and gave a thick, grey, ſtinking ſmoke. Mr Georgi took the bundle out of the cheſt, and laid it on a ſtone pavement; when, on being expoſed to the free air, there aroſe a ſlow burning flame, a ſpan high, with a ſtrong body of ſmoke. Not long afterwards there appeared, here and there, ſeveral chaps or clefts, as from a little volcano, the vapour iſſuing from which burſt into flame. On his breaking the lump, it burſt into a very violent flame, full three feet high, which ſoon grew leſs, and then went out. The ſmoking and glowing fire laſted for the ſpace of ſix hours; and afterwards the remainder continued to glow without ſmoke for two hours longer. The grey earthy aſhes, when cold, weighed five ounces and a half.

In another experiment, perfectly ſimilar to the foregoing, as far as relates to the compoſition and quantities, the enkindling did not enſue till 41 hours after the impregnation: the heat kept increaſing for three hours, and then the accenſion followed. It is worthy of remark, that theſe experiments ſucceeded better on bright days than on ſuch as were rainy; and the accenſion came on more rapidly.

In another experiment, three pounds of Ruſſian fir-black were ſlowly impregnated with three pounds of raw hemp-oil; and the accenſion enſued after nine hours.

Three quarters of a pound of German *rahm* were ſlowly impregnated with a pound and a half of hemp-oil varniſh. The mixture remained 72 hours before it became hot and reeking: it then gradually became hotter, and emitted a ſtrong exhalation; the effluvia were moiſt, and not inflammable. The reaction laſted 36 hours; during which the heat was one while ſtronger, and then weaker, and at length quite ceaſed.

Stove or chimney ſoot, moſtly formed from birch-wood ſmoke, was mingled with the above-mentioned ſubſtances, and tied up; the compound remained cold and quiet.

Ruſſian fir-black, mixed with equal parts of oil of turpentine, and bound up, exhibited not the leaſt reaction or warmth.

Birch oil, mixed with equal parts of Ruſſian fir-black, and bound up, began to grow warm and to emit a volatile ſmell; but the warmth ſoon went off again.

The inſtances of ſpontaneous inflammation hitherto mentioned have been only of vegetable ſubſtances; but we have examples of the ſame thing in the animal kingdom. Pieces of woollen cloth, which had not been ſcoured, took fire in a warehouſe. The ſame thing happened to ſome heaps of woollen yarn; and ſome pieces of cloth took fire in the road, as they were going to the fuller. Theſe inflammations always take place where the matters heaped up preſerve a certain degree of humidity, which is neceſſary to excite a fermentation; the heat reſulting from which, by drying the oil, leads them inſenſibly to a ſtate of ignition; and the quality of the oil, being more or leſs deſiccative, very much contributes thereto.

The

The woollen ftuff prepared at Sevennes, which bears the name of Emperor's ftuff, has kindled of itfelf, and burnt to a coal. It is not unufual for this to happen to woollen ftuffs, when in hot fummers they are laid in a heap in a room but little aired.

In June 1781, the fame thing happened at a woolcomber's in a manufacturing town in Germany, where a heap of wool-combings, piled up in a clofe warehoufe feldom aired, took fire of itfelf. This wool had been by little and little brought into the warehoufe; and, for want of room, piled up very high, and trodden down, that more might be added to it. That this combed wool, to which, as is well known, rape-oil mixed with butter is ufed in the combing, burnt of itfelf, was fworn by feveral witneffes. One of them affirmed that, ten years before, a fimilar fire happened among the flocks of wool at a clothier's, who had put them into a cafk, where they were rammed hard, for their eafier conveyance. This wool burnt from within outwards, and became quite a coal; it was very certain that neither fire nor light had been ufed at the packing, confequently the above fires arofe from fimilar caufes. In like manner, very credible cloth-workers have certified, that, after they have brought wool that was become wet, and packed it clofe in their warehoufe, this wool has burnt of itfelf; and very ferious confequences might have followed, if it had not been difcovered in time.

Nay, there are inftances, though they be but rare, of human bodies being confumed by fpontaneous inflammation. In the Philofophical Tranfactions, and in the Memoirs of the Academies of Paris and Copenhagen, it is related that an Italian lady (the Countefs Cornelia Bandi) was entirely reduced to afhes, except her legs; that an Englifh woman, called Grace Pitt, was almoft entirely confumed by a fpontaneous inflammation of her vifcera; and, laftly, that a prieft of Bergamo was confumed in the fame manner. Thefe fpontaneous inflammations have been attributed to the abufe of fpirituous liquors; but though the victims of intemperance are indeed very numerous, thefe certainly do not belong to that number.

The mineral kingdom alfo often affords inftances of fpontaneous inflammation. Pyrites heaped up, if wetted and expofed to the air, take fire. Pitcoal alfo, laid in heaps, under certain circumftances, inflames fpontaneoufly. M. Duhamel has defcribed two inflammations of this nature, which happened in the magazines of Breft, in the years 1741 and 1757. Cuttings of iron, which had been left in water, and were afterwards expofed to the open air, gave fparks, and fet fire to the neighbouring bodies. For this obfervation we are obliged to M. de Charpentier.

The caufes of thefe phenomena the chemift will affign; but they are here recorded as a warning to tradefmen and others. It is evident, from the facts which have been related, that fpontaneous inflammations being very frequent, and their caufes very various, too much attention and vigilance cannot be ufed to prevent their dreadful effects. And confequently it is impoffible to be too careful in watching over public magazines and ftorehoufes, particularly thofe belonging to the ordnance, or thofe in which are kept hemp, cordage, lampblack, pitch, tar, oiled cloths, &c. which fubftances ought never to be left heaped up, particularly if they have any moifture in them. In order to prevent any accident from them, it would be proper to examine them often, to take notice if any heat is to be obferved in them, and, in that cafe, to apply a remedy immediately. Thefe examinations fhould be made by day, it not being advifable to carry a light into the magazines; for when the fermentation is fufficiently advanced, the vapours which are difengaged by it are in an inflammable ftate, and the approach of a light might, by their means, fet fire to the fubftances whence they proceed. Ignorance of the fore-mentioned circumftances, and a culpable negligence of thofe precautions which ought to be taken, have often caufed more misfortunes and lofs than the moft contriving malice: it is therefore of great importance that thefe facts fhould be univerfally known, that public untility may reap from them every poffible advantage.

INFORMED Stars, or Informes Stellæ, are fuch ftars as have not been reduced into any conftellation; otherwife called Sporades.—There was a great number of this kind left by the ancient aftronomers; but Hevelius, and fome others of the moderns, have provided for the greater part of them, by making new conftellations.

Sympathetic INK is an old invention. Among the methods by which Ovid teaches young women to deceive their guardians, when they write to their lovers, he mentions that of writing with new milk, and of making the writing legible by coal-duft or foot.

Tuta quoque eft, fallitque oculos, e lacte recenti
Litera: carbonis pulvere tange, leges.

It is obvious, that any other colourlefs and glutinous juice, which will hold faft the black powder ftrewed over it, will anfwer the purpofe as well as milk; and therefore Pliny recommends the milky juice of certain plants to be ufed.

There are feveral metallic folutions perfectly colourlefs, or, at leaft, without any ftrong tint, which being wrote with, the letters will not appear until the paper be wafhed over with another colourlefs folution, or expofed to the vapour of it; but among all thefe there is none which excites more aftonifhment, or from which naturalifts can draw more conclufions, than that which confifts of a folution of lead in vegetable acid, and which by the vapour of arfenical liver of fulphur becomes black, even at a confiderable diftance. This ink, which may be ufed by conjurors, proves the fubtlety of vapour, and the porofity of bodies; as the change or colouring takes place even when the writing is placed on the other fide of a thin wall.

We knew before, that a folution of lead, treated in this manner, would anfwer the purpofe of a fympathetic ink (fee that article *Encycl.*); but we did not know, nor do we yet believe, that the fulphuric vapours will act upon the writing through *a wall*. Such, however, is the affirmation of Profeffor Beckmann, who gives an account of a ftill more wonderful ink from Peter Borel. This author, in a book called *Hiftoriarum et obfervationum medico-phyfic. centuriæ quatuor*, printed at Paris, firft in 1653, and afterwards in 1657, gives a receipt for making this ink, which he calls *magnetic waters which act at a diftance*. The receipt is as follows:

"Let quick lime be quenched in common water, and, while quenching, let fome orpiment be added to it (this, however, ought to be done by placing warm afhes under it for a whole day), and let the liquor be filtered, and.

Ink.

and preferved in a glafs bottle well corked. Then boil litharge of gold, well pounded, for half an hour with vinegar, in a brafs veffel, and filter the whole through paper, and preferve it alfo in a bottle clofely corked. If you write any thing with this laft water, with a clean pen, the writing will be invifible when dry; but if it be wafhed over with the firft water it will become inftantly black. In this, however, there is nothing aftonifhing; but this is wonderful, that though fheets of paper without number, and even a board, be placed between the invifible writing and the fecond liquid, it will have the fame effect, and turn the writing black, penetrating the wood and paper without leaving any traces of its action, which is certainly furprifing; but a fetid fmell, occafioned by the mutual action of the liquids, deters many from making the experiment. I am, however, of opinion, that I could improve this fecret by a more refined chemical preparation, fo as that it fhould perform its effect through a wall. This fecret (fays Borel) I received, in exchange for others, from J. Broffon, a learned and ingenious apothecary of Montpelier."

For making a fympathetic ink of the fifth clafs mentioned in the *Encyclopædia*, the following procefs by M. Meyer may be worthy of the reader's notice. It was entered upon in confequence of a receipt for rofe-coloured fympathetic ink fhewn to him by a traveller. In that receipt cobalt was the principal ingredient, and therefore the firft object was to procure cobalt; but M. Meyer, being unwilling to facrifice pure pieces of cobalt of any confiderable fize, made choice of one, which was vifibly mixed with bifmuth, iron, and quartz. He endeavoured to feparate the bifmuth as much as poffible, and alfo the arfenic, if it fhould contain any, by bringing it flowly to a red heat; and he fucceeded pretty well, as the bifmuth flowed from it in abundance; and the arfenic, the quantity of which was fmall, was volatilifed: many globules of bifmuth ftill adhered to it. By bringing it repeatedly to a red heat, and then quenching it in water, it was reduced to fuch a ftate as to be eafily pulverifed. Having poured nitrous acid upon the powder, he obtained by digeftion a beautiful rofe red folution; the filiceous earth was feparated in the form of a white flime, and by diluting it with water there was depofited a white powder, which was oxyd of bifmuth. The folution being filtered, he added to it a folution of potafh, and obtained a precipitate inclining more to a yellow than to a red colour. He again poured over it a little of the nitrous acid, by which a part of the oxyd was re-diffolved of a red colour: the remaining part, which had a dark brown colour, was oxyd of iron. From the folution, by the addition of potafh, a precipitate was formed, which was now reddifh. Having by this procefs obtained it pure, that he might now prepare from it the wifhed-for red ink, he diffolved the wafhen pure oxyd of cobalt in different acids. That diffolved in the nitrous acid with a mixture of nitre, gave a green ink like the common: that diffolved in the fulphurous acid, without the addition of falts, gave a reddifh ink, which remained after it was expofed to heat, and would not again difappear, even when a folution of nitre was applied; and that diffolved in the muriatic acid, gave a green ink, darker and more beautiful than the common. By diffolving it, however, in the acetous acid, and adding a little nitre, he obtained what he had in view; for it gave, on the application of heat, an ink of a red colour, like that of the *rofa centifolia*, which again difappeared when the paper became cold.

Inordinate, Infects.

INORDINATE PROPORTION, is where the order of the terms compared is difturbed or irregular. As, for example, in two ranks of numbers, three in each rank, viz. in one rank, - - - 2, 3, 9, and in the other rank, - - - 8, 24, 36, which are proportional, the former to the latter, but in a different order, viz. - - 2 : 3 : : 24 : 36,
and - - 3 : 9 : : 8 : 24.
then, cafting out the mean terms in each rank, it is concluded that - - - - 2 : 9 : : 8 : 36,
that is, the firft is to the 3d in the firft rank,
as the firft is to the 3d in the 2d rank.

INSECTS (See *Encycl.*). A number of non-defcript little animals was difcovered by La Martiniere the naturalift when accompanying Peroufe on his celebrated voyage of difcovery. Thefe animals he called *infects*, and to many of them he gave particular names. Of thefe we fhall give his defcription in this place, leaving our readers, as he has left his, to arrange them properly according to the Linnæan claffification.

"The infect, which is figured N° 1. inhabits a fmall prifmatic triangular cell, pointed at the two extremities, of the confiftence and colour of clear brittle ice; the body of the infect is of a green colour, fpotted with fmall bluifh points, among which are fome of a golden tinge; it is fixed by a ligament to the lower part of its fmall habitation: its neck is terminated by a fmall blackifh head compofed of three converging fcales, in the form of a hat, and enclofed between three fins, two of them large and channelled in the upper part (A) and one fmall femicircular (B). When it is difturbed, it immediately withdraws its fins and its head into its cell, and gradually finks into the water by its own fpecific gravity. Fig. 2. reprefents the under fide of the prifm, fhewing in what manner it is channelled, in order to allow free paffage to the animal when it wifhes to fhut itfelf up in it. Fig. 3 reprefents the profile of the fame. The movement carried on by the two larger fins, which are of a foftifh cartilaginous fubftance, may be compared to that which would be produced by the two hands joined together in the ftate of pronation, and forming, alternately, two inclined planes and one horizontal plane: it is by means of this motion that it fupports itfelf on the top of the water, where it probably feeds on fat and oily fubftances on the furface of the fea." Our author found it near Nootka, on the north-weft coaft of America, during a calm.

Plate XXX.

Fig. 4. reprefents a collection of infects, as our author calls them, confifting only of oval bodies, fimilar to a foap-bubble, arranged in parties of three, five, fix, and nine: among them are alfo fome folitary ones. Thefe collections of globules, being put into a glafs filled with fea-water, defcribed a rapid circle round the glafs by a common movement, to which each individual contributed by fimple compreffion of the fides of its body, probably the effect of the re-action of the air with which they were filled. It is not, however, eafy to conceive how thefe diftinct animals (for they may be readily feparated without deranging their economy) are capable of concurring in a common motion. "Thefe confiderations (fays our author), together with the form of the animal, recalled to my mind, with much fatisfaction, the ingenious fyftem of M. de Buffon; and I endeavoured to perfuade myfelf, that I was about to be witnefs

Insects, Institute.

ness to one of the most wonderful phenomena of Nature, supposing that these molecules, which were now employed in increasing or diminishing their number, or performing their revolutions in the glass, would soon assume the form of a new animal of which they were the living materials. My impatience led me to detach two from the most numerous group, imagining that this number might perhaps be more favourable to the expected metamorphosis. I was, however, mistaken. These I examined with more attention than the rest; and the following account is of their proceedings alone. Like two strong and active wrestlers, they immediately rushed together, and attacked each other on every side: sometimes one would dive, leaving its adversary at the surface of the water; one would describe a circular movement, while the other remained at rest in the centre; their motions at length became so rapid as no longer to allow me to distinguish one from the other. Having quitted them for a short time, on my return I found them reunited as before, and amicably moving round the edge of the glass by their common exertions."

Fig. 5. represents a singular animal, which has a considerable resemblance to a little lizard; its body is of a firm, gelatinous consistence; its head is furnished on each side with two small gelatinous horns, of which the two hindermost are situate the furthest inward: its body is provided with four open fan-like paws, and some appendages near the insertion of the tail, and terminates like that of a lizard; the ridge of the back is divided the whole way down by a band of a deep blue; the rest of the body, as well as the inside of its paws, is of a bright silvery white. It appears to be very sluggish in its motions; and when disturbed by the finger, merely turned itself belly upwards, soon afterwards resuming its former position. Fig. 6. represents it reversed. Martiniere caught it during a calm at the landing place on the Bashee Islands.

INSTITUTE is a name which has lately been substituted for *school* or *academy*. Formerly *institution*, in the propriety of the English language, was sometimes used as a word of the same import with *instruction*; and now *institute* is employed, especially by the admirers of French innovations, to denote what had hitherto been called an academy. When royalty was abolished in France, it would have been absurd to continue the titles *Royal* Academy of Sciences, *Royal* Academy of Inscriptions, &c.; but instead of merely abolishing the word *royal*, and substituting *national* in its stead, it occurred to the fertile brain of Condorcet, to abolish the seven academies themselves, or rather to melt them all down into one great academy; to which was given the appellation of the

National INSTITUTE, or *New Academy of Arts and Sciences*. This academy, founded on a decree of the new constitution, was opened on the 7th of December 1795, when BENEZECH, the then minister for the home department, attended, and the decree of foundation was read; which was to the following purport:

"The Academy of Arts and Sciences belongs to the whole republic, and Paris is its place of residence. Its employment is to aim at bringing all arts and sciences to the utmost perfection of which they are capable. It is to notice every new attempt, and all new discoveries, and to keep up a correspondence with all foreign literary societies. And by the particular orders of the Executive Directory, its first studies are to be directed to those subjects which more immediately tend to the reputation and advantage of the French republic."

The academy is to consist of 288 members, half of whom are to reside in Paris, the other half in the departments; and to them is to be added a certain number of foreigners, as honorary members, confined at present to twenty-four.

The academy is divided into three classes, each class into sections, each section to contain twelve members.

1st class. Mathematics and natural philosophy. This class is divided into ten sections 1. Mathematics. 2. Mechanical arts. 3. Astronomy. 4. Experimental philosophy. 5. Chemistry. 6. Natural history. 7. Botany. 8. Anatomy and animal history. 9. Medicine and surgery. 10. Animal œconomy, and the veterinary science.

2d class. Morality and politics. This class consists of six sections. 1. Analysis of sensations and ideas. 2. Morals. 3. Legislature. 4. Political economy. 5. History. 6. Geography.

3d class. Literature and the fine arts. This class consists of eight sections. 1. Universal grammar. 2. Ancient languages. 3. Poetry. 4. Antiquities. 5. Painting. 6. Sculpture. 7. Architecture. 8. Music.

For each class a particular room in the Louvre is appropriated. No one can be a member of two classes at the same time, but a member of one class may be present at the meetings of any other. Each class is to print, yearly, an account of its transactions.

Four times a-year there are to be public meetings. On these occasions, the three classes meet together. At the end of each year, they are to give a circumstantial account to the legislative body of the progress made in that year in the arts and sciences. The prizes given yearly by each class are to be publicly notified at certain times. The sums requisite for the support of the institution are to be decreed yearly by the legislative body, upon a requisition made by the Executive Directory.

The first forty-eight members were chosen by the Executive Directory, to whom the choice of the remaining members was confided. To the members, residentiary in Paris, is reserved the choice both of the department and the foreign members. On a vacancy in any class, three candidates are named by the class for the choice of the body at large.

Each class is to have, as its place of meeting, a collection of the products, both of nature and art, and a library, according to its particular wants.

The regulations of the institution, with respect to the times of meeting, and its employments, are to be drawn up by the body at large, and laid before the legislative assembly.

The hall in which the body at large holds its meetings, forms part of the west wing of the Old Louvre, at present called the Museum. It formerly went by the appellation of the Hall of Antiques (*Salle des Antiques*); and as long as the kings inhabited this part of the palace was occupied by their guards, from which circumstance it obtained the name of the Hall *de Cent Suisses*. It was likewise appropriated to banquets and entertainments, given by the court on gala days; and it was to this place that Henry IV. was conveyed, on his assassination by Ravaillac, in the *Rue de la Ferronnerie*.

It was built at the same time with the rest of this part

part of the Louvre, about the year 1528, after the designs of Pierre Lescot, abbot of Clagny. It is 144 feet in length, and 40 in breadth, and holds from 1000 to 1200 persons. In order to adapt it to its new destination the floor has been sunk, which gives a greater air of lightness to the roof. In the centre stands a double table, in the form of a horse-shoe, supported by sphinxes, at which the members of the institute take their seats. This table is surrounded by two tiers of benches, which are raised for the accommodation of spectators, who have likewise seats provided for them in the vast embrasures of the windows, and at each extremity of the hall.

Whether science will be advanced by the seven royal academies having been melted into one, time must determine; but candour compels us to acknowledge, that the proceedings of the national institute have hitherto been abundantly interesting. Intimately connected with the national institute is the French system of

National Instruction, which is likewise novel, and therefore sufficiently curious to deserve notice in a Work of this kind. When the Christian religion was abolished in France, it was impossible to continue the universities and other seminaries which were founded by Christians, and obliged by their constitution to teach, whether pure or not, the doctrines of Christianity. They were accordingly all swept away, and a new system of education planned, which was to be carried on in what they call

The primary Schools.
The Central Schools.
The School of Health.
The School of Oriental Languages.
The Polytechnic School.
The National Institute.
The Jury of Public Instruction.
The Commission of Public Instruction.
The Legislative Committee of Instruction. And various other national establishments for the improvement of particular sciences.

The first degree of public instruction is to be met with in the *Ecoles Primarées*, established by a decree of the convention of the second *Pluvoise*, in the second year of the republic (A). Every district is furnished with one of these schools; the professors or masters in which are paid from the national treasury; and to which every head of a family, without exception, is compelled by law to send its children for instruction. The subjects taught in these primary or elementary schools are divided into nine classes:

1st, Instructions connected with the physical and moral situation of children, prior to their entering into these schools. *2d*, Similar instructions as a guide to teachers in the national schools. *3d*, The arts of reading and writing. *4th*, The elements of French grammar. *5th*, Elements of arithmetic and geometry, with the theory of the new mensuration. *6th*, The elements of geography. *7th*, Explanations of the principal phenomena and productions of nature. *8th*, Elements of agriculture. *9th*, Elements of republican morals.

Next to the primary schools in rank and consequence are the *Ecoles Centrales*, which were established by a decree of the Convention of the seventh *Ventose* in the third year. They are situated in the capital of every department, bearing the proportion of one central school to 300,000 inhabitants. In these schools the republican youths are taught the sciences, and their application in real life. In each of them are professors for the following branches:

1. For mathematics. 2. Experimental philosophy and chemistry. 3. Natural history. 4. Agriculture and commerce. 5. Logic and metaphysics. 6. Political economy and legislation. 7. The Philosophical history of nations. 8. The art of healing. 9. Arts and manufactures. 10. Universal grammar. 11. The belles lettres. 12. The ancient languages. 13. The modern languages. 14. The fine arts.

Each central school is furnished with an extensive public library—a botanic garden—a cabinet of natural history—an apparatus for experimental philosophy—and a collection of machines and models connected with the arts and manufactures.

The professors of each school hold, every month, a public sitting, in which conferences are held relative to subjects connected with the improvement of letters, the sciences, and the arts, which are the most beneficial to society.

The object in the establishment of the primary and central schools was, the general instruction of all classes of the citizens; and it being incompatible with the perfect completion of that important purpose, to expect from them the propagation of particular branches of science, it became necessary to establish other literary and scientific academies.

Accordingly, the French government have founded, *1st*, Schools of health (*les ecoles de sante*), in Paris, Strasburgh, and Montpelier, where medicine and surgery are studied; which schools are affirmed, by those who find nothing wrong in France, to be the most perfect of their kind, as well as new and unparalleled models for such institutions.

2d, Two schools for Oriental languages, in the national library, and in the college of France.

3d, The Polytechnic school in Paris, or central school for the direction of public works. This establishment is very generally admired and considered as a model for imitation. It contains more than 400 young persons, previously educated in the mathematics, and the majority of them intended for engineers in various lines; and they labour under the immediate direction of their tutors nine hours every day. It occupies the principal part of the *Palais de Bourbon* in Paris, and is furnished with a large collection of instruments and models. The journal of the Polytechnic school, which is published by the booksellers Regent and Bertrand at Paris, is a perfectly original work, and admirably calculated to convey useful information.

Of

(A) We would translate this chronological jargon into the language of Christian Europe, were we not persuaded that the French kalendar, the French constitution, and the French institutes, will have the same duration: we trust in God not a long duration. For *Pluvoise*, and the other fantastical names of months introduced into this article, see Revolution, *Encycl.* n° 184.

Of the national institute, a sufficient account has been given in the preceding article. We proceed therefore to the jury of public instruction *(Le Jury Central d'Instruction)*, of which the principal business is to superintend the primary and central schools. It appoints the professors in these schools, and examines into their conduct. Like the legislative body, it is renewed by a third every half year. When they have chosen a professor for a central school, they submit their choice to the department; and, in case of disapprobation, they make another appointment. To this jury of public instruction, the professors in the central schools are amenable for all misconduct connected with their offices; it may expel them, but all its decisions must be submitted for confirmation to the tribunal of the department.

There is also established at Paris a supreme council, called the Commission of Public Instruction, to which is entrusted the whole executive department. The preservation of the national monuments, of public libraries, museums, cabinets, and valuable collections; the superintendence of all the schools and the modes of instruction; all new inventions and scientific discoveries; the regulation of weights and measures; national statistics and political economy, are all placed under the authority of this supreme commission. For the commodious and regular execution of so many complicated branches of business, there is a large office, called *Le Secretariat*, which is divided into three departments.

1. For the regulation of the different kinds of instruction; of the modes of education in the schools; and for the choice of elementary books. 2. For weights and measures; inventions and discoveries; libraries and bibliography; museums, works of art, and literary rewards and encouragements. 3. For theatres, national feasts, republican institutions, and the erection of monuments.

As all public establishments require the superintendance and occasional correction of the legislature, in addition to that of their own immediate executive authority, it has been deemed necessary to appoint a permanent committee of instruction in the legislative body, to provide such sums as may be necessary for the preservation and improvement of this system of instruction. This legislative committee are invested with due authority for these purposes. Their objects are precisely the same as those of the commission of public instruction above described, only with this difference, that the latter superintends the execution of existing laws, whilst the former recives and improves them, or proposes new ones. This committee is divided into three departments, as is the commission, with exactly the same arrangement of their respective labours. The committee being charged with the enaction of all new laws, its members, with a view to obtain accurately all the requisite information relative to the numerous branches of the arts, have procured from the legislative body the appointment of a *commission temporaire des arts* to be annexed to them, and to meet in the same house with them; which temporary commission is divided into sixteen classes: viz. 1. For Zoology; 2. Botany; 3. Mineralogy; 4. Physics; 5. Chemistry; 6. Anatomy; 7. Machinery; 8. Geography; 9. Artillery and Fortification; 10. Medals and Antiquities; 11. Bibliography; 12. Painting; 13. Architecture; 14. Sculpture; 15. Bridges and Causeways; and, 16. Musical Instruments.

The improvements of the national literary and scientific establishments are numerous and important.

1st, By a decree of the convention of the 11th *Prairial*, in the second year, it was enacted that means should be adopted by which every possible advantage might be derived from the botanic gardens of the republic, in Turkey and other foreign countries. This politic decree clearly tended to render France, in the language of the reporter, *L'abregé de tous les climats, et l'entrepôt de l'Europe.* "The epitome of every climate, and the magazine of Europe." Those plants which thrive between the tropics may be cultivated in the south of France; and those which are the produce of northern climates, may be cultivated in the northern departments; by which means France will be in possession of all foreign plants and drugs, without the exportation of specie.

2d, The National Bibliography was decreed in the sitting of 22d *Germinal*, in the second year. It consists of a complete catalogue of books of all descriptions, the property of the nation; it was then ascertained that the republic possessed more than ten millions of books. The titles of them were to be adjusted by actual comparisons; the manuscripts to be registered separately; anonymous productions were to be arranged according to their subjects; and those of known authors in the alphabetical order of the names. The several editions to be classed according to their dates; and what may be deemed more important, this French National Bibliography will contain a dictionary of anonymous books, as well as those published under fictitious names, a desideratum in the republic of letters.

3d, The annihilation of all *patois*, or dialects, decreed in the sitting of the 16th *Prairial*, in the second year. Notwithstanding the universality of the French language, and that it was exclusively spoken in the majority of the inland departments, yet there existed thirty various dialects in France. It is more astonishing that Rozier had remarked, that between one neighbouring village and another, there was so considerable a difference in the dialect, that the inhabitants could not understand each other; and the vinestock had thirty different names. The naturalist Villars has stated, that in the nomenclature of vegetables, in the departments, he had only met with an hundred which had a common appellation.

4th, The establishment of the *Conservatoire des Arts et Métiers*, was decreed in the sitting of the 8th of *Vendemiaire*, in the third year. This consists of a spacious hall, in the form of an amphitheatre, and contains the instruments and the models of machinery connected with the arts, and a description of their uses, with every book relating to them. Annexed to this establishment are three expositors and a draughtsman, who explain to the students the use of each instrument, and who register every new discovery, which is presented to the *Bureau de Consultation*, to the lyceum of arts, the *cidevant* academy of sciences, or to the board of commerce.

5th, The establishment of the board of longitude was decreed in the sitting of the 7th of *Messidor*, third year. It was certainly a disgrace under the monarchy, that an astronomical and nautical establishment, which had already proved so beneficial to Great Britain, should not have been adopted in France. In consequence of this decree, the French board is now as complete as the

 English.

Institute. English. It consists of ten members, and has under its jurisdiction the national observatory at Paris, and all the astronomical instruments belonging to the republic. It corresponds with foreign astronomers; delivers public lectures on astronomy and navigation; and its proceedings are annually recited in a public sitting.

6*th*, The general school of the Oriental languages was established by a decree of the 10th of *Germinal*, in the fourth year. This school adjoins to the national library, and all the books and manuscripts relative to Oriental literature are deposited in it.

7*th*, The national museum of antiquities was decreed in the sitting of 20th of *Prairial*, fourth year. A school of this description was succesfsully established at Vienna, by Eckel; at Gottingen, by Heyne; at Leipsick, by Ernest; and even at Strasburgh, by the celebrated Obeilin; Paris was, however, without one. This national archeology, or science of antiquity, is divided into nine different classes: inscriptions, characters, statues, *bas reliefs*, sculptures, paintings, mosaics, medals, civil, religious, and military instruments. This extensive establishment is under the direction of two principal professors; *le Conservateur Professeur, et le Conservateur Bibliothecaire.* The province of the former is to deliver public lectures on the several branches of antiquities, to teach the theory of medals and engravings, the history of the arts among the ancients, &c. The duties of the latter are merely of a bibliographical nature.

8*th*, The new modelling of the Grand National Library, was decreed in the sitting of 25th *Vendemiare*, in the fourth year. By virtue of this decree, the place of librarian in chief was suppressed, and the whole establishment placed under a *conservatoire* of eight members; of whom two were appointed for the superintendence of printed books; two for manuscripts; two for antiquities; and two for engravings. From these a temporary director is annually chosen, who superintends the whole acts occasionally as president of this assembly, and maintains a regular correspondence with the constituted authorities relative to the concerns of the library.

9*th*, The augmentation of the Museum of Natural History, formerly called *Le Jardin Royal des Plantes*, This establishment was decreed the 15th *Brumaire*, third year, upon a report of Thibadeau, in the name of the committee of Public Instruction. Besides the addition of large rooms, and various other buildings, there are new collections of natural curiosities and productions; and the library is much increased. It is open to the public three times a week. At stated periods all the naturalists in Paris deliver courses of lectures in the various branches of natural history. The museum is said to have received greater improvements from this augmentation than from all the labours of Buffon, or from its foundation, since the time of Tournefort.

10*th*, The *Ecole des Mines* was established in the *Hotel des Monnaies*, and has for its direction the naturalist Le Sage. This institution is unrivalled in Europe; and the collection of mineralogical curiosities surpasses whatever can be conceived.

11*th*, The society of natural history in Paris, deservedly classes among those which have rendered the greatest services to the cause of science since the revolution. A lecture of public instruction is held every ten days, which is generally given by one of the members, and which is open to all the lovers of natural history. Premiums are proposed for dissertations; one of which, by the late C. Herman, junior (whose early decease was a great loss to the republic of letters), on the *apterous* class of insects, may be said to constitute an epocha in the annals of natural history. The society has published a volume of memoirs, in folio, entitled, "*Transactions of the Society of Natural History.*" It has likewise erected a statue to the great Linnæus, in the national garden of plants; and, at the period when every public instruction was suspended, gave lectures on the different branches of science belonging to its department. Several intelligent and skilful navigators, among others those sent in search of the unfortunate La Perouse, as well as those which accompanied Buonaparte on his romantic expedition to Egypt, were members of this society.

This statement of facts relative to the present state of public instruction, the sciences, the arts, and the progress of national literature in France, has been taken from a miscellany, of which the principal writers are well acquainted with what is doing in that distracted country. They call it a sublime system; and seem to consider the increase of the national library, the improvement of the botanic gardens, and the discoveries that have been made by the different schools or institutes, as furnishing a demonstration that the republican government is more favourable to the advancement of science, than the monarchical, whether absolute or limited. But it should not be forgotten, that this system is yet in its infancy; and that in prosecuting new schemes, all men, and more especially Frenchmen, are actuated by an enthusiasm which gradually cools as their pursuits become familiar. We shall therefore venture to predict, that the different schools will not display such ardour seven years hence as they do at present; and that if the republican government continue a dozen of years in France, the progress of science in that country will not be more rapid than it was under the monarchy. We must remember, too, that the French libraries, museums, and picture galleries, have been improved by means which the morals of other governments do not employ —by rapine and robbery.

That something may be learned from this system to improve the modes of education in other countries, we admit; and it is for that reason that we have inserted an account of it. But if it contains something worthy of imitation, it contains likewise much to be shunned. We do not think it consistent with the *rights of man* to *compel* parents to send their children to be educated in *particular* schools; especially in schools where not only religious instruction is omitted, but where, there is reason to believe, that the professors are at pains to raze all religious impressions from the youthful mind. In a nation denying the truth of Christianity, it is not to be supposed that the Christian religion will be publicly taught; but in a nation of philosophers, as the French call themselves, it might have been expected that the laws of religious toleration would have been so far regarded, that Christian parents would not have been *compelled* to send their children to *antichristian* schools! But it is not Christianity alone that is neglected in this *sublime* system of education. Though the legislative body has some time ago decreed that there is a God, there

there is not in any one of thofe fchools the fmalleft care taken to inftruct the republican youth in the principles even of natural religion! We might indeed have looked for it under the title *Metaphyfics*, had not the conftitution of the National Inftitute taught us, that French metaphyfics attend to nothing but the analyfis of fenfations and ideas. Yet the legiflators might have liftened on this fubject to a republican as found as themfelves, and who was likewife no friend to fuperftition. "Nam et Majorum inftituta tueri facris, ceremoniifque retinendis fapientis eft. Non folum ad religionem pertinet, fed etiam ad *civitatis* ftatum, ut fine iis, qui facris publice præfunt, religioni privatæ fatisfacere non poffint." *Cicero de Nat. Deorum.*

INSURANCE, in law and commerce, though an excellent inftitution, is not of high antiquity. The oldeft laws and regulations concerning infurance, with which the indefatigable Beckmann is acquainted, are the following:

On the 28th of January 1523, five perfons appointed for that purpofe drew up at Florence fome articles which are ftill employed on the exchange at Leghorn. Thefe important regulations, together with the prefcribed form of policies, which may be confidered as the oldeft, have been inferted, in Italian and German, by Magens, in his Treatife on Infurance, average, and bottomry, publifhed at Hamburgh in 1753.

There is ftill preferved a fhort regulation of the 25th May 1537, by the Emperor Charles V. refpecting bills of exchange and infurance, in which the ftrictly fulfilling only of an agreement of infurance is commanded.

In the year 1556, Philip II. king of Spain gave to the Spanifh merchants certain regulations refpecting infurance, which are inferted by Magens, with a German tranflation, in his work before mentioned. They contain fome forms of policies on fhips going to the Indies.

In the year 1598, the *Kamer von affurantie*, chamber of infurance, was eftablifhed at Amfterdam. An account of the firft regulations of this infurance office may be feen in Pontanus's Hiftory of the city of Amfterdam, and in other works.

In the year 1600, regulations refpecting infurance were formed by the city of Middleburg in Zealand.

It appears that the firft regulations refpecting infurances in England, which may be feen in *Anderfon's Hiftory of Commerce*, were made in the year 1601. We find by them, that infurers had before that period conducted themfelves in fuch a manner, that the utmoft confidence was repofed in their honefty, and that on this account few or no difputes had arifen.

Of the various policies for infurance in England, a pretty accurate account will be found in the *Encyclopædia*; but there is one of them of which our account muft be acknowledged to be now defective. This is,

Insurance on Lives; which is a policy that has greatly increafed, in confequence of its utility being more generally underftood. Of the two offices for life affurances, noticed in that article, the former, entitled the *Amicable Society*, has extended the number of its fhares to 4000; but, as we have already obferved, the nature of the inftitution is too limited to become of general importance. The latter, entitled, the *Society for equitable Affurances on Lives and Survivorfhip*, is undoubtedly one of the moft important inftitutions of the kind, as will appear by the following account, with which we have been favoured by an obliging correfpondent, and upon the accuracy of which our readers may depend.

The members of the Equitable Society, finding, in June 1777, that their affairs were in a flourifhing fituation, refolved to reduce their annual premiums one-tenth; and in 1782 adopted new tables, agreeable to the probabilities of life at Northampton, in lieu of thofe they had hitherto ufed, formed from the London bills of mortality. But though it was evident that the new tables were much better adapted for affuring promifcuoufly perfons refiding in the country, or in large towns, it was thought proper, for greater fecurity, to make an addition of 15 per cent. to the real value of the affurances, as computed from the table of mortality at Northampton; and with the view of making an adequate compenfation to the affured for their former payments, which had been fo much higher than would be required by the new rates, an addition was made to their claims of L. 1, 10s. per cent. for every premium they had paid. The confequence of thefe meafures proved highly favourable to the Society; for its bufinefs increafed fo faft, that in 1785 it was nearly doubled; the fums affured amounting to upwards of L. 720,000. At this period, the favourable refult of a minute and very laborious inveftigation of the ftate of the Society, induced them to take off the 15 per cent. charged upon the premiums in 1782, and make a further addition to the claims of L. 1 per cent. for every payment made prior to the 1ft January 1786. A ftill greater increafe of fuccefsful bufinefs determined them, in 1791, to make another addition of L. 1 per cent. to the claims; and in the following year, a further addition of L. 2 per cent.; by which the claims upon affurances of the year 1770 were more than doubled; and thofe of an earlier date increafed in a ftill higher proportion. By thefe advantages to its members, and the honourable and truly equitable manner in which the concerns of the Society are tranfacted, the augmentation of their bufinefs has been fo great, that on the 31ft December 1792, the fums affured (without including the additions made to them) amounted to upwards of L. 3,000,000; and on the 31ft December 1795, to about L. 4,000,000.

The rates of affurance, as reduced to their real values in 1786, and according to which the Society now tranfact bufinefs, are as follows:

Sum Affured £. 100.

Age.	One Year.	Seven Years.	Whole Life
15	£. 0 17 11	£. 1 2 11	£. 1 18 7
20	1 7 3	1 9 5	2 3 7
25	1 10 7	1 12 1	2 8 1
30	1 13 3	1 14 11	2 13 4
35	1 16 4	1 18 10	2 19 10
40	2 0 8	2 4 1	3 7 11
45	2 6 8	2 10 10	3 17 11
50	2 15 1	3 0 8	4 10 10
55	3 5 0	3 12 0	5 6 4
60	3 18 1	4 7 1	6 7 4
65	4 15 2	5 10 10	7 16 9

The

The other offices in London for the aſſurance of lives are, the *Royal Exchange Aſſurance*, the *Weſtminſter Society*, and the *Pelican Life Office*.

The corporation of the *Royal Exchange Aſſurance* was empowered to aſſure lives by its ſecond charter, dated 29th April 1721; but the original object of the company being ſea aſſurances, and the true principles of aſſuring on lives being at that time little underſtood, this branch of their buſineſs was at firſt comparatively ſmall: they generally required a premium of five or ſix guineas per cent. without any regard to the age; and the aſſurance, which was uſually for a ſmall ſum, was ſeldom for a greater term than one year. In this manner they continued to aſſure upon lives till the end of the year 1783, when the increaſing importance of this part of their buſineſs, which they had ſome years felt, induced them to adopt a regular table of rates of aſſurance, according to the Northampton regiſters of mortality, but with a greater addition to the real values than had been made by the "Society for Equitable Aſſurances on Lives and Survivorſhip." This was thought proper, from the conſideration that the aſſurers with the Royal Exchange Company are not in any caſe liable to a call upon them beyond the premium they engage to pay, and have the ſecurity of the capital and funds of the company ariſing from the other branches of their buſineſs; however, the company, finding themſelves ſucceſsful in their life aſſurances, determined, in 1790, to reduce their premiums; and in 1797 made a ſtill greater reduction, by which they are brought very near to thoſe above ſtated. This company have agents in all the principal towns of Great Britain, and are impowered to aſſure lives in all parts of the world.

The *Weſtminſter Society* was eſtabliſhed in 1792, for aſſuring lives, and granting annuities. Their terms are nearly the ſame as thoſe of the Royal Exchange Aſſurance; but not being a corporate body, every perſon aſſuring ſigns a declaration, that he accepts the joint ſtock of the ſociety as his ſecurity.

The *Pelican Life Office* was inſtituted in 1797, by ſome of the principal proprietors of the Phœnix Fire Office. The rates which they have publiſhed vary conſiderably from thoſe of the other offices: but whether they are founded on more juſt principles, time and experience muſt determine. This ſociety alſo makes a new ſpecies of aſſurance, by way of endowment for daughters, or for children generally, when they ſhall attain the age of twenty-one years.

INTEGRAL calculus, in the new analyſis, is the reverſe of the differential calculus, and is the finding of the integral from a given differential; being ſimilar to the inverſe method of fluxions, or the finding the fluent to a given fluxion. See Fluxions, *Encycl.*

INTEREST, is the allowance given for the uſe of money by the borrower to the lender, and is either *ſimple* or *compound*. The method of computing both intereſts is explained in the article Algebra (*Encycl.*), page 427, &c.; and the ſubject of ſimple intereſt is again reſumed in Arithmetic (*Encycl.*), n° 20. The application of the canons for the computation of compound intereſt, to the value of annuities, the only caſe in which that intereſt is allowed by the laws of this country, may be ſeen in the articles Annuity and Survivorship (*Encycl.*); where various tables are given to facilitate the different computations. Some of our readers, however, have expreſſed a wiſh to have the rule for computing compound intereſt ſo ſtated, as to be underſtood by thoſe who are unacquainted with algebraic ſymbols. Their wiſh may be eaſily gratified.

The general formula $S = p\,R^t$ anſwers for the amount of any ſum, whether the intereſt be payable yearly, half-yearly, quarterly, or daily. Let R denote the amount of one pound for the firſt payment, and t the number of payments, the unit being from the commencement till the firſt payment is due; alſo, let l denote the logarithm of any quantity before which it is wrote; then, from the known property of logarithms, the theorem may be expreſſed thus, $l.\,S = l.\,p + l.\,R \times t$.

Required the amount of L. 250 at 5 per cent. compound intereſt, for 12 years, reckoning the intereſt payable yearly, half-yearly, quarterly, and daily?

Yearly, $p = 250$, $R = 1{\cdot}05$, $t = 12$.

$$\begin{array}{rl}
0{\cdot}0211893 & = l.\,R \\
12 & \\ \hline
{\cdot}2542716 & = l.\,R \times t \\
2{\cdot}3979400 & = l.\,p \\ \hline
l.\,S = 2{\cdot}6522116 & \text{— L. } 448 : 19 : 3\tfrac{1}{4} = \text{Amount.} \\
 & \quad\;\; 250 \\ \hline
 & \quad\;\; 198 : 19 : 3\tfrac{1}{4} = \text{Comp. Int.}
\end{array}$$

Half-yearly, $p = 250$, $R = 1{\cdot}025$, $t = 24$.

$$\begin{array}{rl}
0{\cdot}0107239 & = l.\,R \\
24 & \\ \hline
428956 & \\
214478 & \\ \hline
{\cdot}2573736 & = l.\,R \times t \\
2{\cdot}3979400 & = l.\,p \\ \hline
l.\,S = 2{\cdot}6553136 & \text{— L. } 452 : 3 : 7\tfrac{1}{4} = \text{Amount.} \\
 & \quad\;\; 250 \\ \hline
 & \quad\;\; 202 : 3 : 7\tfrac{1}{4} = \text{Intereſt.}
\end{array}$$

Quarterly, $p = 250$, $R = 1{\cdot}0125$, $t = 48$.

$$\begin{array}{rl}
0{\cdot}0053950 & = l.\,R \\
48 & \\ \hline
431600 & \\
215800 & \\ \hline
{\cdot}2589600 & = l.\,R \times t \\
2{\cdot}3979400 & = l.\,p \\ \hline
l.\,S = 2{\cdot}6569000 & \text{— L. } 453 : 16 : 8\tfrac{1}{4} = \text{Amount.} \\
 & \quad\;\; 250 \\ \hline
 & \quad\;\; 203 : 16 : 8\tfrac{1}{4} = \text{Intereſt.}
\end{array}$$

Daily. $p = 250,\ R = 1 + \frac{\cdot05}{365} = \frac{365\cdot05}{365},\ t = 365 \times 12.$

$$\begin{array}{l} 2\cdot5623524 \\ 2\cdot5622929 \\ \hline \cdot0000595 = l.\ R \\ \quad 4380 \\ \hline \quad 47600 \\ \quad 1785 \\ \quad 2380 \\ \hline \cdot2606100 = l.\ R \times t \\ 2\cdot3979400 = l.\ p. \\ \hline \end{array}$$

$l.\ S = 2\cdot6585500$ — L.455 : 11 : $3\frac{1}{2}$ = Amount.
250

205 : 11 : $3\frac{1}{2}$ = Intereft.

INTERPOLATION, in the modern algebra, is ufed for finding an intermediate term of a feries, its place in the feries being given. See ALGEBRA and SERIES, *Encycl.*

The method of interpolation was firft invented by Mr Briggs, and applied by him to the calculation of logarithms, &c. in his Arithmetica Logarithmica, and his Trigonometria Britannica; where he explains, and fully applies, the method of interpolation by differences. His principles were followed by Reginal and Mouton in France, and by Cotes and others in England. Wallis made ufe of the method of interpolation in various parts of his works: as his arithmetic of infinites, and his algebra, for quadratures, &c. The fame was alfo happily applied by Newton in various ways: by it he inveftigated his binomial theorem, and quadratures of the circle, ellipfe, and hyperbola. See Wallis's Algebra, chap. 85. &c. Newton alfo, in lemma 5. lib. 3. Princip. gave a moft elegant folution of the problem for drawing a curve line through the extremities of any number of given ordinates; and in the fubfequent propofition, applied the folution of this problem to that of finding, from certain obferved places of a comet, its place at any given intermediate time. And Dr Waring, who adds, that a folution ftill more elegant, on fome accounts, has been fince difcovered by Meff. Nichol and Stirling, has alfo refolved the fame problem, and rendered it more general, without having recourfe to finding the fucceffive differences. *Philof. Tranf.* vol. 69. part 1. art. 7.

INTERSCENDENT, in algebra, is applied to quantities, when the exponents of their powers are radical quantities. Thus $x^{\sqrt{2}}$, $x^{\sqrt{a}}$, &c. are interfcendent quantities.

INTERSTELLER, a word ufed by fome authors to exprefs thofe parts of the univerfe that are without and beyond the limits of our folar fyftem.

INTRADOS, the interior and lower fide, or curve, of the arch of a bridge, &c. In contradiftinction from the extrados, or exterior curve, or line on the upper fide of the arch. See ARCH in this *Suppl.*

INVOLUTION and EVOLUTION, are terms introduced into geometry by the celebrated Mr Huyghens, to exprefs a particular manner of defcribing curvilineal fpaces which occurred to him when occupied in the improvement of his noble invention of pendulum clocks. Although he was even aftonifhed at the accuracy of their motion, and they foon fuperfeded all balance clocks, he knew that the wide vibrations were fomewhat flower than the narrow ones, and that a circle was not fufficiently incurvated at the fides to render all the vibrations ifochronous. The proper curve for this purpofe became an interefting object. By a moft accurate inveftigation of the motions of heavy bodies in curved paths, he difcovered that the cycloid was the line required. Lord Brouncker had difcovered the fame thing, as alfo Dr Wallis. But we do not imagine that Huyghens knew of this; at any rate, he has the full claim to the difcovery of the way of making a pendulum ofcillate in a cycloidal arch. It eafily occurred to him, that if the thread by which the pendulum hangs be fufpended between two curved cheeks, it would alternately lap on each of them in its vibrations, and would thus be raifed out of the circle which it defcribes when fufpended from a point. But the difficulty was to find the proper form of thefe cheeks. Mr Huyghens was a moft excellent geometer, and was poffeffed of methods unknown to others, by which he got over almoft every difficulty. In the prefent cafe there was fortunately no difficulty, the means of folution offering themfelves almoft without thought. He almoft immediately difcovered that the curve in queftion was the fame cycloid. That is, he found, that while a thread unwinds from an arch of a cycloid, beginning at the vertex, its extremity defcribes the complementary arch of an equal cycloid.

Thus he added to this curve, already fo remarkable for its geometrical properties, another no lefs curious, and infinitely exceeding all the others in importance.

The fteps by which this property was difcovered are fuch direct emanations from general principles, that they immediately excited the mind of Mr Huyghens, which delighted in geometry, to profecute this method of defcribing or transforming curve lines by evolution. It is furprifing that it had not ere this time occurred to the ancient geometers of the laft century; and particularly to Dr Barrow, who feems to have racked his fancy for almoft every kind of motion by which curve lines can be generated. Evolution of a thread from a curve is a much more obvious and conceivable genefis than that of the cycloid invented by Merfennus, or that of the conchoid by Nicodemes, or thofe of the conic fections by Vieta. But except fome vague expreffions by Ptolemy and Gaffendus, about defcribing fpirals by a thread unlapped from a cylinder, we do not recollect any thing of the kind among the writings of the mathematicians; and it is to Huyghens alone that we are indebted for this very beautiful and important branch of geometry. It well deferves both of thefe epithets. The theorems which conftitute the doctrines of evolution are remarkable for their perfpicuity and neatnefs. Nothing has fo much contributed to give us clear notions of a very delicate fubject of mathematical difcuffion, namely curvature, and the meafure and variations of curvature. It had become the fubject of very keen debate; and the notions entertained of it were by no means diftinct. But nothing can give fuch a precife conception of the difference of curvature, in the different parts of a cycloid or other curve, as the beholding its defcription by a radius continually varying in length. This doctrine is peculiarly valuable to the fpeculator

Involution. culator in the higher mechanics. The intensity of a deflecting force is estimated by the curvature which it induces on any rectilineal motion; and the variations of this intensity, which is the characteristic of the force, or what we call its nature, is inferred from the variations of this curvature. The evolution and involution of curve lines have therefore great claim to our attention. But a Work like ours can only propose to exhibit an outline of the subject; and we must refer our readers to those eminent authors who have treated it in detail. Varignon, in the Memoirs of the French Academy for 1706, has been at immense pains to present it in every form; James Bernoulli has also treated the subject in a very general and systematic manner. Some account is given of it in every treatise of fluxions. We recommend the original work of Mr Huyghens in particular; and do not hesitate to say, that it is the finest specimen (of its extent) of physico-mathematical discussion that has ever appeared. Huyghens was the most elegant of all modern geometers; and both in the geometrical and physical part of this work, *De Horologio Oscillatorio*, he has preserved the utmost rigour of demonstration, without taking one step in which Euclid or Apollonius would not have followed him.

——— *juvat integros accedere fontes*
Atque haurire.

Such authors form the taste of the young mathematician, and help to preserve him from the almost mechanical procedure of the expert symbolical analyst, who arrives at his conclusion without knowing how he gets thither, or having any notions at all of the magnitudes of which he is treating.

There are two principal problems in his doctrine.

I. To ascertain the nature of the figure generated by the evolution of a given curve.

II. To determine the nature of the curve by whose evolution a given curve may be generated.—We shall consider each of these in order, and then take the opportunity which this subject gives of explaining a little the abstruse nature of curvature, and its measures and variations, and take notice of the opinions of mathematicians about the precise nature of the angle of contact.

Plate XXXI. The curve line ABCDEF (fig. 1.) may be considered as the edge of a crooked ruler or mould; a thread may be supposed attached to it at F, and then lapped along it from F to A. If the thread be now led away from A, keeping it always tight, it is plain that the extremity A must describe a curve line A b c d e f, and that the detached parts of the thread will always be tangents to the curve ABCDEF. In like manner will the curve line F d' c' b' A' be described by keeping the thread fast at A, and unlapping it from the other end of the mould.

This process was called by Mr Huyghens the Evolution of the curve ADF. ADF is called the Evolute. A d f was named by him the Curve by Evolution. It has been since more briefly termed the Evolutrix, or unlapper. It has also been called the Involute; because, by performing the process in the opposite direction f d A, the thread is lapped up on the mould, and the whole space ADF f d A is folded up like a fan. The detached parts C c, D d, or C c', D d', &c. of the thread, are called Radii of the Evolute; perhaps with some impropriety, because they rather resemble the momentary radii of the evolutrix. We may name them the evolved radii. The beginning A of evolution may be considered as the vertex of the curves, and the ends F and f may be called the terms.

There is another way in which this description of curve lines may be conceived. Instead of a thread F f gradually lapped up on the mould, we may conceive F f to be a straight edged ruler applied to the mould, and gradually rolled along it without sliding, so as to touch it in succession in all its points. It is evident, that by this process the point f will describe the curve f d A, while the point F describes the other curve F d' a. This way of conceiving it gives a great extension to the doctrine, and homologates it with that genesis of curve lines by which cycloids of all kinds are described, and which we may distinguish by the name of Provolution. For it is plain that the relative motions of the points A and b are the same, whether the ruler b B b' roll on the mould ABF, or the mould roll on the ruler: but there will be a great difference in the form of the line traced by the describing point, if we suppose the plane on which it is traced to be attached to the rolling figure. Thus, when a circle rolls on a straight line, a point in its circumference traces a cycloid on the plane attached to the straight line, while the point of the straight line which quitted the circle describes on the plane attached to the circle another line; namely, the involute of the circle. This mode of description allows us to employ a curved ruler in place of the straight one b B b'; and thus gives a vast extension to the theory. But at present we shall confine ourselves to the employment of the straight line b B b', only keeping in mind, that there is an intimate connection between the lines of evolution and of provolution.

By the description now given of this process of evolution and involution, it is plain,

1. That the evolution is always made from the convex side of the evolute.

2. That the evolved radii B b, C c, D d, &c. are respectively equal to the arches BA, CA, DA, &c. of the evolute which they have quitted; and that b B b', c C c, d D d', &c. are always equal to the whole arch ADF.

3. That any point B of the lapped up thread describes during its evolution a curve line B γ δ ϵ φ parallel to b c d e f; because these curves are always equidistant from each other.

4. That if the thread extend beyond the mould as a tangent to it, the extremity α will describe a parallel or equidistant curve α β γ δ ϵ φ, lying without A b c d e f. From this it appears that B γ δ ϵ φ is the complete evolutrix of FEDCB, while b d c e f is the evolutrix of that arch, and the added tangent B b. In like manner, the lapped up thread ADF, with the added part F φ', describes the evolutrix φ' ϵ' δ' γ' β' A'.

5. If from any point C of the evolute there be drawn lines C b, C c, C d, C e, &c. to the evolutrix, those which are more remote from the vertex are greater than those which are nearer. Draw B b, c C, d D, e E, touching the evolute. C b is less than CB + B b; that is (2), than C c. Again, DC + C c is equal to D d, which is less than DC + C d. Therefore C c is less than C d. Now let C e cut D d in r. Then e r + r DE is greater than e E. But e E is equal to d r + r DE. Therefore e r is greater than d r; and e r + r C

Involution. rC is greater than $dr + r$C, which is greater than cC. Therefore eC is greater than cC.

6. Hence it follows, that a circle defcribed round any point of the evolute, with a radius reaching to any point of the evolutrix, will cut the evolutrix in that point, and be wholly within it on the fide remote from the vertex, and without it on the fide next the vertex.

7. The evolved radius cuts every arch of the evolutrix perpendicularly, or a right line drawn through the interfection at right angles touches the evolutrix in that point. Through any point d draw the line $m\,d\,t$ at right angles to dD. The part of it $m\,d$ next to the vertex is wholly without the curve, becaufe it is without the circle defcribed round the centre D; and this circle is without the evolutrix on that fide of d which is next the vertex (6). Any point t on the other fide of d is alfo without the curve. For let $t\,e$E be another evolved radius, cutting Dd in n: then $n\,d$ is lefs than $n\,t$, becaufe $n\,d\,t$ is a right angle by conftruction; and therefore $n\,t\,d$ is acute. But becaufe En + nD are greater than ED, En + $n\,d$ are greater than ED + Dd, that is, than Ee, and $n\,d$ is greater than $n\,e$. Therefore, fince it is lefs than $n\,t$, it follows that $n\,e$ is much lefs than $n\,t$, and t lies without the curve. Therefore the whole line $m\,d\,t$ is without the curve, except in the point d. It therefore touches the curve in d, and the radius Dd cuts it at right angles in that point. By the fame reafoning, it is demonftrated that all the curves A$b\,d\,f$, $\alpha\beta\delta\varsigma$, A$'b'd'f'$, $\alpha'\beta'\delta'\varsigma'$, are cut perpendicularly by the tangents to the evolute. Alfo all thefe curves interfect the evolute at right angles in their vertexes.

It follows from this propofition, that from every point, fuch as s, or i, or o, &c. in the fpace AOF comprehended by the evolute and its extreme tangents AO, FO, two perpendiculars may be drawn to the evolutrix A$d\,f$; and that from any point in the fpace within the angle A$o\,f$ only one perpendicular can be drawn; and that no perpendicular can be drawn from any point on the other fide of ADF. Apollonius had obferved thefe circumftances in the conic fections, but had not thought of marking the boundary formed by the evolute ADF. Had he noticed this, he would certainly have difcovered the whole theory of evolution, and its importance in fpeculative geometry.

It alfo follows from this propofition, that if a curve A$b\,c\,d\,e\,f$ is cut by the tangents of ABCDEF at right angles in every point, it will be defcribed by the evolution of that curve: For if the evolutrix, whofe vertex is A, be really defcribed, it will coincide with A$b\,c\,d$ in A, and have the fame tangent; it therefore does not deviate from it, otherwife their tangents would feparate, and would not both be at right angles with the lines touching the evolute. They muft therefore coincide throughout.

8. The arches $b\,c\,d$ and $\beta\gamma\delta$, intercepted by fome radii Bb and Dd, may be called *concentric;* and the angles contained between the tangents drawn through their extremities are equal. Thus the angle $\lambda\pi o$ is equal to $l\,p\,o$: but although equidiftant, parallel, and containing the fame angle between their tangents and between their radii, they are not fimilar. Thus, the arch $\alpha\beta$ has a curvature at α that is the fame with that of any circle whofe radius is equal to Aα; but the curvature at A is incomparable with it, and unmeafurable. The fame may be faid of the curvatures at β and at B.

9. If a circle $u\,d\,z$ be defcribed round the centre D with the radius Dd, it both touches and cuts the evolutrix in the point d, and no circle can be defcribed touching the curve in that point, and paffing between it and the circle $u\,d\,z$: For fince it touches the curve in d, its centre muft be fomewhere in the line dD perpendicular to $m\,d\,t$. It cannot be in any point n more remote from d than D is; for it would pafs without the arch $d\,u$, and be more remote than $d\,u$ from the arch $d\,c$ of the evolutrix. On the other fide, it would indeed pafs without the arch $d\,z$, which lies within the arch $d\,e$ of the evolutrix: but it would alfo pafs without the curve. For it has been already demonftrated (7) that $n\,d$ is greater than $n\,e$; and the curve would lie between it and the circle $d\,z$.

Thus it appears, that a circle defcribed with the evolved radius approaches nearer to the curve, or touches it more clofely, than any other circle; all other circles either interfect it in meafurable angles, or are within or without the curve on both fides of the point of contact. This circle $u\,d\,z$ has therefore the fame curvature with the curve in the point of contact and coalefcence. It is the EQUICURVE CIRCLE, the circle of equal curvature, the OSCULATING CIRCLE (a name given it by Leibnitz). The evolved radius of the evolute is the RADIUS OF CURVATURE of the evolutrix, and the point of the evolute is the CENTRE OF CURVATURE at the point of contact with the evolutrix. The evolute is the geometrical locus of all the centres of curvature of the evolutrix.

This is the moft important circumftance of the whole doctrine of the involution and evolution of curve lines. It is affumed as a felf-evident truth by the precipitant writers of elements. It is indeed very like truth: For the extremity of the thread is a momentary radius during the procefs of evolution; and any minute arch of the evolute nearer the vertex muft be conceived as more incurvated than the arch at the point of contact, becaufe defcribed with fhorter radii: for the fame reafon, all beyond the contact muft be lefs incurvated, by reafon of the greater radii. The curvature at the contact muft be neither greater nor lefs than that of the circle. But we thought it better to follow the example of Huyghens, and to eftablifh this leading propofition on the ftricteft geometrical reafoning, acknowledging the fingular obligation which mathematicians are under to him for giving them fo palpable a method of fixing their notions on this fubject. When the evolute of a curve is given, we have not only a clear view of the genefis of the curve, with a neat and accurate mechanical method of defcribing it, but alfo a diftinct comprehenfion of the whole curvature, and a connected view of its gradual variations.

We fpeak of curvature that is greater and leffer; and every perfon has a general knowledge or conception of the difference, and will fay that an ellipfis is more curve at the extremities of the tranfverfe axis than any where elfe. But before we can inftitute a comparifon between them with a precifion that leads to any thing, we muft agree about a meafure of curvature, and fay what it is we mean by a double or a triple curvature. Now there are two ways in which we may confider curvature, or a want of rectitude: We may call that a double curvature which, in a given fpace, carries us twice as far from the ftraight line; or we may call that a double curvature by which we deviate twice as much from

from the fame direction. Both of thefe meafures have been adopted; and if we would rigidly adhere to them, there would be no room for complaint: but mathematicians have not been fteady in this refpect, and by mixing and confounding thefe meafures, have frequently puzzled their readers. All agree, however, in their firft and fimple meafures of curvature, and fay that the curvature of an arch of a circle is as the arch directly, and as the radius inverfely. This is plainly meafuring curvature by the deflection from the firft direction. In an arch of an inch long, there is twice as much deflection from the firft direction when the radius of the circle is of half the length. If the radius is about $57\frac{1}{4}$th inches, an arch of one inch in length produces a final direction one degree different from the firft. If the radius is $114\frac{1}{2}$ inches, the deviation is but half of a degree. The linear deflection from the ftraight path is alfo one half. In the cafe of circles, therefore, both meafures agree: but in by far the greateft number of cafes they may differ exceedingly, and the changes of direction may be greateft when the linear deviation is leaft. Flexure, or change of direction, is, in general, the moft fenfible and the moft important character of curvature, and is underftood to be its criterion in all cafes. But our proceffes for difcovering its quantity are generally by firft difcovering the linear deviation; and, in many cafes, particularly in our philofophical inquiries, this linear deviation is our principal object. Hence it has happened, that the mathematician has frequently ftopped fhort at this refult, and has adapted his theorems chiefly to this determination. Thefe differences of object have caufed great confufion in the methods of confidering curvature, and led to many difputes about its nature, and about the angle of contact; to which difputes there will be no end, till mathematicians have agreed in their manner of expreffing the meafures of curvature. At prefent we abide by the meafure already given, and we mean to exprefs by curvature or flexure the change of direction.

This being premifed, we obferve, that the curvature of all thefe curves of evolution where they feparate from their evolutes, is incomparable with the curvature in any other place. In this point the radius has no magnitude; and therefore the curvature is faid to be infinitely great. On the other hand, if the evolved curve has an afymptote, the curvature of the evolutrix of the adjacent branch is faid to be infinitely fmall. Thefe expreffions becoming familiar, have occafioned fome very intricate queftions and erroneous notions. There can be little doubt of their impropriety: For when we fay, that the curvature at A is infinitely greater than at α, we do not recollect that the flexure of the whole arch A b is equal to that of the whole arch $\alpha\,\beta$, and the flexure at A muft either make a part of the whole flexure, or it muft be fomething difparate.

The evolutrix A $b\,c\,d\,e\,f$ (fig. 2.) of the common equilateral hyperbola exhibits every poffible magnitude of curvature in a very fmall fpace. At the vertex A of the hyperbola it is perpendicular to the curve; and therefore has the tranfverfe axis A τ A″ for its tangent. The curvature of the evolutrix at A is called infinitely great. As the thread unlaps from the branch ABC, its extremity defcribes A $b\,c$. It is plain that the evolutrix muft cut the affymptote φ H at right angles in fome point G, where the curvature will be what is called infinitely fmall; becaufe the centre of curvature has removed to an infinite diftance along the branch AF of the hyperbola. This evolutrix may be continued to the vertex of the hyperbola on the other fide of the affymptote, by caufing the thread to lap upon it, in the fame way that Mr Huyghens completed his cycloidal ofcillation. Or we may form another evolutrix $\alpha\,\beta\,\gamma\,\delta\,\varphi\,\gamma'\,\delta'\,\beta'$ A″, by lengthening the thread from G to τ, the centre of the hyperbola, and fuppofing that, as foon as the curve A $\delta\,\varphi$ is completed, by unlapping the thread from the branch ABC, another thread laps upon the hyperbola A″ F″. This laft is confidered as a more geometrical revolution than the other: For the mathematicians, extending the doctrine of evolution beyond Mr Huyghens's reftriction to curves which had their convexity turned one way, have agreed to confider as one continued evolution whatever will complete the curve expreffed by one equation. Now the fame equation expreffes both the curves AF and A″F″, which occupy the fame axis AA″. The cycloid employed by Huyghens is, in like manner, but one continuous curve, defcribed by the continued provolution of the circle along the ftraight line, although it appears as two branches of a *repeated* curve. We fhall meet with many inftances of this feemingly compounded evolution when treating of the fecond queftion.

Since the arch A $b\,d$ G contains every magnitude of curvature, it appears that every kind of curvature may be produced by evolution. We can have no conception of a flexure that is greater than what we fee at A, or lefs than what we fee at G; yet there are cafes which feem to fhew the contrary, and are familiarly faid, by the greateft mathematicians, to exhibit curvatures infinitely fmaller ftill. Thus, let ABC (fig. 3) be a conical parabola, whofe parameter is AP. Let AEF be a cubical parabola, whofe parameter is AQ. If we make AQ to AD as the cube of AP to the cube of AQ, the two parabolas will interfect each other in the ordinate DB. For, making AP $= p$, and AQ $= q$, and calling the ordinate of the conic parabola y, that of the cubic parabola z, and the indeterminate abfciffa AD x, we have

$$p^3 : q^3 = q : x, = q^3 : z^3, \text{ and } p : q = q : z;$$

but $q : p = q : p$; therefore, by compofition,

$$p^2 : q^2 = q^2 : p\,x = q^2 : y^2, \text{ and } p : q = q : y;$$

therefore $z = y$, and the parabolas interfect in B.

Now, becaufe in all parabolas the ordinates drawn at the extremity of the parameters are equal to the parameters, the interfections q and p will be in a line A $q\,p$, which makes half a right angle with the axis AP. Therefore, when AQ is greater than AP, the point q is without the conical parabola, and the whole arch of the cubical parabola cut off by the ordinate DB is alfo without it; but when AQ is lefs than AP, q is within the conical parabola, as is alfo the arch q B. Therefore the remaining arch BEA is without it, and is therefore lefs incurvated at A. An endlefs number of conical parabolas of fmaller curvature may be drawn by enlarging AP; yet there will ftill be an arch AEB of the cubical parabola which is without it, and therefore lefs incurvated. Therefore the curvature of a cubical parabola of lefs than that of any conical parabola: It is faid to be infinitely lefs, becaufe an infinity of cubical parabolas of *fmaller curvature* than AEB may be drawn by enlarging AQ.

It

It may be demonſtrated in the ſame manner, that a paraboloid, whoſe ordinates are in the ſubſiquuadrate ratio of the abſciſſæ, has an infinitely ſmaller curvature at the vertex than the cubical parabola. And the curvature of the paraboloid of the next degree is infinitely leſs than this; and ſo on continually. Nay, Sir Iſaac Newton, who firſt took notice of this remarkable circumſtance, demonſtrates the ſame thing of an endleſs ſucceſſion of paraboloids interpoſed between any two degrees of this ſeries. *Neque novit* (ſays he) *natura limitem.*

If this be the caſe, all curves cannot be deſcribed by evolution; for we have no conception of a radius of curvature that is greater than a line without limit. The theory of curvilineal motions delivered in the article Dynamics muſt be imperfect, or there muſt be curve lines which bodies cannot deſcribe by any powers of nature. The theory there delivered profeſſes to teach how a body can be made to deſcribe the cubical parabola, and many other curves which have theſe infiniteſimal curvatures; and yet its demonſtrations employ the radius of curvature, and cannot proceed without it. We profeſs ourſelves obliged to an attentive reader (who has not favoured us with his name) for making this obſervation. It merits attention.

There muſt be ſome paralogiſm or miſconception in all this language of the mathematicians. It does not neceſſarily follow from the arch AEB lying without the arch AIB, that it is leſs incurvated at A; it may be more incurvated between A and B. Accordingly we ſee, that the tangent BT of the conical parabola is leſs inclined to the common tangent AV than the tangent B*t* of the cubical parabola is; and therefore the flexure of the whole arch AEB is greater than that of the whole arch AIB; and we ſhall ſee afterwards, that there is a part of AEB that is more incurvated than any part of AIB. There is nothing correſponding to this unmeaning and inconceivable ſucceſſion of ſerieſes of magnitudes of one kind, each of which contains an endleſs variety of individuals, and the greateſt of one ſeries infinitely leſs than the ſmalleſt of the next, &c.; there is nothing like this demonſtrated by all our arguments. In none of theſe do we ever treat of the curvature at A, but of a curvature which is *not* at A. At A we have none of the lines which are indiſpenſably neceſſary for the demonſtration. Beſides, in the very ſame manner that we can deſcribe a cubical parabola, and prove that it has an arch lying without the conical parabola, we can deſcribe a circle, and demonſtrate that it has alſo an arch lying without the parabola. Theſe infiniteſimal curvatures, therefore, are not warranted by our arguments, nor does it yet appear that there are curves which cannot be deſcribed by evolution. We are always puzzled when we ſpeak of infinites and infiniteſimals as of ſomething preciſe and determinate; whereas the very denomination precludes all determination. We take the diſtinguiſhing circumſtance of thoſe different orders for a thing clearly underſtood; for we build much on the diſtinction. We conceive the curvature of the cubical parabola as verging on that of the common parabola, and the one ſeries of curvatures as beginning where the other ends. But Newton has ſhewn, that between theſe two ſerieſes an endleſs number of ſimilar ſerieſes may be interpoſed. The very names given to the curvature at the extremities of the hyperbolic evolutrix have no conceptions annexed to them. At the vertex of the hyperbola there is no line, and at the interſection with the aſſymptote there is no curvature. Theſe unguarded expreſſions, therefore, ſhould not make us doubt whether all curves may be deſcribed by evolution. If a line be incurvated, it is not ſtraight. If ſo, two perpendiculars to it muſt diverge on one ſide, and muſt converge and meet on the other in ſome point. This point will lie between two other points, in which the two perpendiculars touch that curve by the evolution, of which the given arch of the curve may be deſcribed. Finally (which ſhould decide the queſtion), we ſhall ſee by and bye, that the cubic, and all higher orders of paraboloids, may be ſo deſcribed by evolution from curves having aſſymptotic branches of determinable forms.

Such are the general affections of lines generated by evolution. They are not, properly ſpeaking, peculiar properties; for the evolutrixes may be any curve lines whatever. They only ſerve to mark the mutual relations of the evolutes with their evolutrixes, and enable us to conſtruct the one, and to diſcover its properties by means of our knowledge of the other. We proceed to ſhew how the properties of the evolutrix may be determined by our knowledge of the evolute.

This problem will not long occupy attention, being much limited by the conditions. One of the firſt is, that the length of the thread evolved muſt be known in every poſition: Therefore the length of the evolved arch muſt, in like manner, be known; and this, not only *in toto*, but every portion of it. Now this is not univerſally, or even generally the caſe. The length of a circular, parabolic, hyperbolic, arch has not yet been determined by any finite equation, or geometrical conſtruction. Therefore their evolutrixes cannot be determined otherwiſe than by approximation, or by compariſon with other magnitudes equally undetermined. Yet it ſometimes happens, that a curve is diſcovered to evolve into another of known properties, although we have not previouſly diſcovered the length of the evolved arch. Such a diſcovery evidently brings along with it the rectification of the evolute. Of this we have an inſtance in the very evolution which gave occaſion to the whole of this doctrine; namely, that of the cycloid; which we ſhall therefore take as our firſt example.

Let ABC (fig. 5.) be a cycloid, of which AD is the axis, and AHD the generating circle, and AG a tangent to the cycloid at A, and equal to DC. Let BKE touch the cycloid in B, and cut AG in K. It is required to find the ſituation of that point of the line BE which had unfolded from A?

Draw BH parallel to the baſe DC of the cycloid, cutting the generating circle in H, and join HA. Deſcribe a circle KEM equal to the generating circle AHD, touching AG in K, and cutting BK in ſome point E. It is known, by the properties of the cycloid, that BK is equal and parallel to HA, and that BH is equal to the arch A*h*H. Becauſe the circles AHD and KEM are equal, and the angles HAK and AKE are equal, the chords AH and KE cut off equal arches, and are themſelves equal. Becauſe BHAK is a parallelogram, AK is equal to HB; that is, to the arch A*h*H, that is, to the arch K*m*E. But if the circle KEM had been placed on A, and had rolled from A to K, the arch diſengaged would have been equal to AK, Involution. AK, and the point which was in contact with A would now be in E, in the circumference of a cycloid AEF, equal to CBA, having the line AG, equal and parallel to DC, for its base, and GF, equal and parallel to DA, for its axis. And if the diameter KM be drawn, and EM be joined, EM touches the cycloid AEF.

Cor. The arch BA of the cycloid is equal to twice the parallel chord HA of the generating circle: For this arch is equal to the evolved line BKE; and it has been shewn that EK is equal to KB, and BE is therefore equal to twice BK, or to twice HA. This property had indeed been demonstrated before by Sir Christopher Wren, quite independent of the doctrine of evolution; but it is given here as a legitimate result of this doctrine, and an example of the use which may be made of it. Whenever a curve can be evolved into another which is susceptible of accurate determination, the arch of the evolved curve is determined in length; for it always makes a part of the thread whose extremity describes the evolutrix, and its length is found by taking from the whole length of the thread that part which only touches the curve at its vertex.

This genesis of the cycloid AEF, by evolution of the cycloid ABC, also gives the most palpable and satisfactory determination of the area of the cycloid. For since BE is always parallel to AH, AH will sweep over the whole surface of the semicircle AHD, while BE sweeps over the whole space CBAEF; and since BE is always double of the simultaneous AH, the space CBAEF is quadruple of the semicircle AHD. But the space described in any moment by BK is also one-fourth part of that described by BE. Therefore the area GAEF is three times the semicircle AHD; and the space DHABC is double of it; and the space CBAG is equal to it.

Sir Isaac Newton has extended this remarkable property of evolving into another curve of the same kind to the whole class of epicycloids, that is, cycloids formed by a point in the circumference of a circle, while the circle rolls on the circumference of another circle, either on the convex or concave side; and he has demonstrated, that they also may all be rectified, and a space assigned which is equal to their area (See *Principia*, B. I. prop. 48. &c.) He demonstrates, that the whole arch is to four times the diameter of the generating circle as the radius of the base is to the sum or difference of those of the base and the generating circle. We recommend these propositions to the attention of the young reader who wishes to form a good taste in mathematical researches; he will there see the geometrical principles of evolution elegantly exemplified.

We may just observe, before quitting this class of curves, that many writers, even of some eminence, in their compilations of elements, give a very faulty proof of the position of the tangent of a curve described by rolling. They say, for example, that the tangent of the cycloid at E is perpendicular to KE; because the line KE is, at the moment of description, turning round K as a momentary centre. This, to be sure, greatly shortens investigation; and the inference is a truth, not only when the rolling figure is a circle rolling on a straight line, but even when any one figure rolls on another. Every point of the rolling figure really *begins* to move perpendicularly to the line joining it with the point of contact. But this genesis of the arch Ee, by the evolution of the arch Bb, shews that K is by no means the centre of motion, nor HK the radius of curvature. Nor is it, in the case of epicycloids, trochoids, and many curves of this kind, a very easy matter to find the momentary centre. The circle KEM is both advancing and turning round its centre; and these two motions are equal, because the circle does not slide but roll, the detached arch being always equal to the portion of the base which it quits. Therefore, drawing the tangents Eg, Mg, and completing the parallelogram Ef Mg, Ef will represent the progressive motion of the centre, and Eg the motion of rotation. EM, the motion compounded of these, must be perpendicular to the chord EK.

The investigation that we have given of the evolutrix of the cycloid has been somewhat peculiar, being that which offered itself to Mr Huyghens at the time when he and many other eminent mathematicians were much occupied with the singular properties of this curve. It does not serve, however, so well for exemplifying the general process. For this purpose, it is proper to avail ourselves of all that we know of the cycloid, and particularly the equality of its arch BA to the double of the parallel chord HA. This being known, nothing can be more simple than the determination of the evolutrix, either by availing ourselves of every property of the cycloid, or by adhering to the general process of referring every point to an abscissa by means of perpendicular ordinates. In the first method, knowing that BE is double of BK, and therefore KE equal to HA, and KA = BH, = HbA, = KmE, we find E to be the describing point of the circle, which has rolled from A to K. In the other method, we must draw EN perpendicular to AG; then, because the point E moves, during evolution, at right angles to BE, EK is the normal to the curve described, and NK the subnormal, and is equal to the corresponding ordinate H′I′ of the generating circle of the cycloid ABC. This being a characteristic property of a cycloid, E is a point in the circumference of a cycloid equal to the cycloid ABC.

Or, lastly, in accommodation to cases where we are supposed to know few of the properties of the evolute, or, at least, not to attend to them, we may make use of the fluxionary equation of the evolute to obtain the fluxionary equation of the evolutrix. For this purpose, take a point e very near to E, and draw the evolving radius be, cutting Ef (drawn parallel to the base DC) in o; draw en parallel to the axis of the evolute, cutting Eo in v; also draw bhi parallel to the base, and Bd perpendicular to it. If both curves be now referred to the same axis CGF, it is plain that Bb, Bd, and db are ultimately as the fluxions of the arch, abscis, and ordinate of the evolute, and that Ee, ev, and vE, are ultimately as the fluxions of the arch, abscissa, and ordinate of the evolutrix. Also the two fluxionary triangles are similar, the sides of the one being perpendicular, respectively to those of the other. If both are referred to one axis, or to parallel axes, the fluxion of the abscissa of the evolute is to that of its ordinate, as the fluxion of the ordinate of the evolutrix is to that of its abscissa. Thus, from the fluxionary equation of the one, that of the other may be obtained. In the present case, they may be referred to AD and FG, making CG equal to the cycloidal arch CBA. Call this a; AI, x; IB, y; and AB, or EB, z. In like manner, let

Ft

Ft be $= u$, $tE = v$, and $FE = w$; then, becaufe $DH^2 = DA^2 - AH^2$, and DA and AH are the halves of CF and BE, we have $DH^2 = \frac{a^2 - z^2}{4}$. Alfo $DI = \frac{DH^2}{DA} = \frac{a^2 - z^2}{4 \times \frac{1}{2} a} = \frac{a^2 - z^2}{2a}$. But $DI = Ft$. Therefore Ft, or u, $= \frac{a^2 - z^2}{2a}$. Alfo $\dot{w} = \frac{\dot{u}\dot{z}}{\dot{y}}$, by what was faid above, that is, $\dot{w} = \frac{a\dot{u}}{\sqrt{a^2 - z^2}} = \frac{a\dot{u}}{\sqrt{2au}}$. Therefore we have $\dot{w} : \dot{u}\ (= a : \sqrt{2au}) = \sqrt{\frac{1}{2}a} : \sqrt{u} = \sqrt{GF} : \sqrt{Ft}$, which is the analogy competent to a cycloid whofe axis is $GF = DA$.

It is not neceffary to infift longer on this in this place; becaufe all thefe things will come more naturally before us when we are employed in deducing the evolute from its evolutrix.

When the ordinates of a curve converge to a centre, in which cafe it is called a radiated curve, it is moft convenient to confider its evolutrix in the fame way, conceiving the ordinates of both as infifting on the circumference of a circle defcribed round the fame centre. Spirals evolve into other fpirals, and exhibit feveral properties which afford agreeable occupation to the curious geometer. The equiangular, logarithmic, or loxodromic fpiral, is a very remarkable example. Like the cycloid, it evolves into another equal and fimilar equiangular fpiral, and is itfelf the evolutrix of a third. This is evident on the flighteft infpection. Let $C\,r\,q\,p$ (fig. 6.) be an equiangular fpiral, of which S is the centre; if a radius SC be drawn to any point C, and another radius SP be drawn at right angles to it, the intercepted tangent CP is known to be equal to the whole length of the interior revolutions of the fpiral, though infinite in number. If the thread CP be now unlapped from the arch $C\,r\,q$, it is plain that the firft motion of the point P is in a direction PT, which is perpendicular to PC, and therefore cuts the radius PS in an angle SPT, equal to the angle SCP; and fince this is the cafe in every pofition of the point, it is manifeft that its path muft be a fpiral PQR, cutting the radii in the fame angle as the fpiral $C\,r\,q\,p$. James Bernoulli firft difcovered this remarkable property. He alfo remarked, that if a line PH be drawn from every point of the fpiral, making an angle with the tangent equal to that made by the radius (like an angle of reflection correfponding with the incident ray SP), thofe reflected rays would all be tangents to another fimilar and equal fpiral $I\,v\,H$; fo that $PH = PS$. S and H are conjugate foci of an infinitely flender pencil; and therefore the fpiral $I\,v\,H$ is the cauftic by reflection of RQP for rays flowing from S. If another equal and fimilar fpiral $x\,v\,y$ roll on $I\,v\,H$, its centre z will defcribe the fame fpiral in another pofition $w\,u\,z$. All thefe things flow from the principles of evolution alone: and Mr Bernoulli traces, with great ingenuity, the connection and dependence of cauftics, both by reflection and refraction, of cycloidal, and all curves of provolution, and their origin in evolution or involution. A variety of fuch repetitions of this curve (and many other fingular properties), made him call it the SPIRA MIRABILIS. He defired that it fhould be engraved on his tombftone, with the infcription EADEM MUTATA RESURGO, as expreffive of the refurrection of the dead. See his two excellent differtations in *Act* Erudit. 1692, March and May.

Another remarkable property of this fpiral is, that if, inftead of the thread evolving from the fpiral, the fpiral evolve from the ftraight line PC, the centre S will defcribe the ftraight line PS. Of this we have an example in the apparatus exhibited in courfes of experimental philofophy, in which a double cone defcends, by rolling along two rulers inclined in an angle to each other (fee *Gravefande's* Nat. Phil. I. § 210). It is pretty remarkable, that a rolling motion, feemingly round C, as a momentary centre, fhould produce a motion in the ftraight line SP; and it fhews the inconclufivenefs of the reafoning, by which many compilers of elements of geometry profefs to demonftrate, that the motion of the defcribing point S is perpendicular to the momentary radius. For here, although this feeming momentary radius may be fhorter than any line that can be named, the real radius of curvature is longer than any line that can be named.

But it is not merely an object of fpeculative geometric curiofity to mark the intimate relation between the genefis of curves by evolution and provolution; it may be applied to important purpofes both in fcience and in art. Mr M'Laurin has given a very inviting example of this in his account of the Newtonian philofophy; where he exhibits the moon's path in abfolute fpace, and from this propofes to inveftigate the deflecting forces, and *vice verfa*. We have examples of it in the arts, in the formation of the pallets of pendulums, the teeth of wheels, and a remarkable one in Meffrs Watt and Boulton's ingenious contrivance for producing the rectilineal motion of a pifton rod by the combination of circular motions. M. de la Hire, of the Academy of Sciences at Paris, has been at great pains to fhew how all motions of evolution may be converted into motions of provolution, in a memoir in 1706. But he would have done a real fervice, if, inftead of this ingenious whim, he had fhewn how all motions of provolution may be traced up to the evolution which is equivalent to them. For there is no organic genefis of a curvilineal motion fo fimple as the evolution of a thread from a curve. It is the primitive genefis of a circle; and it is in evolution alone that any curvilineal motion is comparable with circular motion. A given curve line is an individual, and therefore its primitive organical genefis muft alfo be individual. This is ftrictly true of evolution. A parabola has but one evolute. But there are infinite motions of provolution which will defcribe a parabola, or any curve line whatever; therefore thefe are not primitive organical modes of defcription. That this, however, is the cafe, may be very eafily fhewn. Thus let ABCD (fig. 7.) be a parabola, or any curve; and let $a\,b\,c\,d$ be any other curve whatever. A figure $E\,m\,l\,k\,h\,i$ may be found fuch, that while it rolls along the curve $a\,b\,c\,d$, a point in it fhall defcribe the parabola. The procefs is as follows: Let $B\,b$, $C\,c$, $D\,d$, &c. be a number of perpendiculars to the parabola, cutting the curve $a\,b\,c\,d$ in fo many points. The perpendiculars may be fo difpofed that the points a, b, c, &c. fhall be equidiftant. Now we can conftruct a triangle $E\,e\,h$ fo, that the three fides $E\,e$, $e\,h$, and $h\,E$, fhall be refpectively equal to the three lines $E\,e$, $e\,f$, $F\,f$. In like manner may the whole figure be conftructed, having the little bafes of the

 the triangles refpectively equal to the fucceffive portions of the bafe $Abcd$, and the radii equal to the perpendiculars Bb, Cc, Dd, &c. Let this figure roll on this bafe c. While the little fide ck moves from its prefent pofition, and applies itfelf to ef, the point E defcribes an arch E ϵ of a circle round the centre e, and, falling within the parabola, is fomewhere between E and F. Then continuing the provolution, while the next fide hi turns round f till i applies to g, the point E defcribes another arch ϵ F o round f, firft rifing up and reaching the parabola in F, when the line h E coincides with fF, and then falling within the parabola till the point h begin to rife again from f by the turning of the rolling figure round the point g. Reverfing the motion, the fides ih, he, ek, &c. apply themfelves in fucceffion to the portions gf, fe, ed, &c. of the bafe, and the point E defcribes an undulating line, confifting of arches of circles round the fucceffive centres g, f, e, &c. Thefe circular arches all touch the parabola in the points G, F, E, &c. and feparate from it a little internally. By diminifhing the portions of the bafe, and increafing the number of the triangular elements of the rolling figure without end, it is evident that the figure becomes ultimately curvilineal inftead of polygonal, and the point E continues in the parabola, and accurately defcribes it. It is now a curvilineal figure, having its elementary arches equal to the portions of the bafe to which they apply in fucceffion, and the radii converging to E equal to the perpendiculars intercepted between the curve ABCD and the bafe. It may therefore be accurately conftructed.

It is clear that practical mechanics may derive great advantage from a careful ftudy of this fubject. We now fee motions executed by machinery which imitate almoft every animal motion. But thefe have been the refult of many random trials of *wipers*, *fnail-pieces*, &c. of various kinds, repeatedly corrected, till the defired motion is at laft accomplifhed. But it is, as we fee, a fcientific problem, to conftruct a figure which fhall certainly produce the propofed motion; nor is the procefs by any means difficult. But how fimple, in comparifon, is the production of this motion by evolution. We have only to find the curve line which is touched by all the perpendiculars Bb, Cc, Dd, &c. This naturally leads us to the fecond problem in this doctrine, namely, to determine the evolute by our knowledge of the involute: a problem of greater difficulty and of greater importance, as it implies, and indeed teaches, the curvature of lines, its meafure, and the law of its variation in all particular cafes. The evolute of a curve is the geometrical expreffion, and exhibition to the eye, of both thefe affections of curve lines.

Since the evolved thread is always at right angles to the evolutrix and its tangent, and is itfelf always a tangent of the evolute, it follows, that all lines drawn perpendicular to the arch of any curve, touch the curve line which will generate the given curve by evolution. Were this evolved curve previoufly known to us, we could tell the precife point where every perpendicular would touch it; but this being unknown, we muft determine the points of contact by fome other method, and by this determination we afcertain fo many points of the evolute. The method purfued is this: When two perpendiculars to the propofed curve are not parallel (which we know from the known pofition of the tangents of our curve), they muft interfect each other fomewhere on that fide of the tangents where they contain an angle lefs than 180°. But when they thus interfect, one of them has already touched the evolute, and the other has not yet reached it. Thus let bs, es (fig. 1.) be the two perpendiculars: being tangents to the evolute, the points s of their interfection muft be on its convex-fide, and the unknown points of contact B and E muft be on different fides of s. Thefe are elementary truths.

Let eE approach toward bB, and now cut it in x. The contact has fhifted from E to D, and x is ftill between the contacts. When the fhifting perpendicular comes to the pofition cC, the interfection is at i, between the contacts B and C. And thus we fee, that as the perpendiculars to the involute gradually approach, their contacts with the evolute alfo approach, and their interfection is always between them. Hence it legitimately follows, that the ultimate pofition of the interfection (which alone is fufceptible of determination by the properties of the involute) is the pofition of the point of contact, and therefore determines a point of the evolute. The problem is therefore reduced to the inveftigation of this ultimate interfection of two perpendiculars to the propofed curve, when they coalefce after gradually approaching. This will be beft illuftrated by an example: Therefore let ABC (fig. 8.) be a parabola, of which A is the vertex, AH the axis, and AV one-half of the parameter; let BE and CK be two perpendiculars to the curve, cutting the axis in E and K, and interfecting each other in r; draw the ordinates BD, CV, and the tangent BT, and draw BF parallel to the axis, cutting CK in F, and CN in O.

Becaufe the perpendiculars interfect in r, we have $r\mathrm{E} : \mathrm{EB} = \mathrm{EK} : \mathrm{BF}$. If therefore we can difcover the ratio of EK to BF, we determine the interfection r. But the ratio of EK to BF is compounded of the ratio of EK to BO, and the ratio of BO to BF. The firft of thefe is the ratio of equality; for DE and VK are, each of them, equal to AV, or half the parameter. Take away the common part VE, and the remainders EK and DV are equal, and DV is equal to BO; therefore $\mathrm{EK} : \mathrm{BF} = \mathrm{BO} : \mathrm{BF}$; therefore $r\mathrm{E} : r\mathrm{B} = \mathrm{BO} : \mathrm{BF}$, (and by divifion) $\mathrm{BE} : \mathrm{E}r = \mathrm{FO} : \mathrm{OB}$. Now let the point C continually approach to B, and at laft unite with it. The interfection r will unite with a point of contact N on the evolute. The ultimate ratio of FO to OB, or of $fo : o\mathrm{B}$, is evidently that of ED to DT, or ED to 2DA; therefore $\mathrm{BE} : \mathrm{EN} = \mathrm{ED} : 2\mathrm{DA}$, or as half the parameter to twice the abfciffa. Thus have we determined a point of the evolute; and we may, in like manner, determine as many as we pleafe.

But we wifh to give a general character of this evolute, by referring it to an axis by perpendicular ordinates. It is plain that V is one point of it, becaufe the point E is always diftant from its ordinate DB by a line equal to AV; and therefore, when B is in A, E will be in V, and r will coincide with it. Now draw VP and NQ perpendicular to AH, and NM perpendicular to VP; let EB cut PV in t: then, becaufe AV and DE are equal, AD is equal to VE, and VE is equal to one-half of DT. Moreover, becaufe BD and NQ are parallel, $\mathrm{DE} : \mathrm{EQ} = \mathrm{BE} : \mathrm{EN} = \mathrm{DE} : \mathrm{DT}$; therefore $\mathrm{DT} = \mathrm{EQ}$, and $\mathrm{VE} = \frac{1}{2}\mathrm{EQ}$, and therefore

$= \frac{1}{3}$

$=\frac{1}{3}$VQ; therefore Vt is $\frac{1}{3}$ of Mt, and $\frac{1}{4}$ MV. This is a characteriſtic property of the evolute. The ſubtangent is $\frac{3}{2}$ of the abſciſſa; in like manner, as in the common parabola, it is double of the abſciſſa. We know therefore that the evolute is a paraboloid, whoſe equation is $a\,x^2=y^3$; that is, the cube of any ordinate MN is equal to the parallelopiped whoſe baſe is the ſquare of the abſciſſa VM, and altitude a certain line VP, called the parameter. To find VP, let CR be the perpendicular to the parabola in the point where it is cut by the ordinate at V; draw the ordinate RS of the paraboloid, and RG perpendicular to AH. Then it is evident, from what has been already demonſtrated, that VK is $\frac{1}{2}$ of KG, and $\frac{1}{3}$ of VG: therefore KG^2 $=4$VK^2, and (in the parabola) VC$^2=2$VK^2. Alſo, becauſe KV : VC = KG : GR, we have GR$^2=2$KG^2 $=8$VK^2; therefore VP × RG$^2=8$VP × VK^2. But VG$^3=27$VK^3, $=27$VK × VK^2; therefore, becauſe in the paraboloid, VP × VS^2 = SR^3, or VP × RG^2 = VG^3, we have 8 VP × VK^2 = 27 VK × VK^2, and 8 VP = 27 VK; or VK : VP; that is, AV : VP = 8 : 27; or VP = $\frac{27}{8}$ AV, or $\frac{27}{16}$ of the parameter of the parabola ABC. The evolute of the conical parabola is the curve called the ſemicubical parabola, and its parameter is $\frac{27}{16}$ of the conical parabola.

This inveſtigation is nearly the ſame with that given by Huyghens, which we prefer at preſent to the method generally employed, becauſe it keeps the principle of inference more cloſely in view.

Mr Huyghens has deduced a beautiful corollary from it. Since the parabola ABC is deſcribed by the evolution of the paraboloid VNR, the line RC is equal to the whole evolved arch RNV, together with the redundant tangent line AV. If therefore we take from CR a part C$\varkappa$ equal to the redundant AV, the remainder $\varkappa$ R is equal to the arch RNV of the paraboloid. We may do this for every poſition of the evolved radius, and thus obtain a ſeries of points V, β, $\varkappa$, δ, ϵ, of the evolutrix of the paraboloid. We have even an eaſier method for obtaining the length of any part of the arch of the parabaloid, without the previous deſcription of the parabola ABC. Suppoſe Py the arch of the paraboloid, and $y\,z$ the tangent; make Pz = $\frac{8}{27}$ of the parameter, and deſcribe the arch P$u\,u$ of a circle; then draw from every tangent $y\,z$ a parallel line $x\,v$, cutting the circle in u. The length of the arch y P is equal to $y\,z+u\,v$. The celebrated author congratulates himſelf, with great juſtice, on this neat exhibition of a right line equal to the arch of a curve, without the employment of any line higher than the circle. It is the ſecond curve that has been ſo rectified, the cycloid alone having been rectified by plain geometry a very few years before by Sir Chriſtopher Wren. It is very true, and he candidly admits it, that this very curve had been rectified before by Mr William Neill, a young gentleman of Oxford, and favourite pupil of Dr Wallis; as alſo by Mr Van Heuraet, a Dutch gentleman of rank, and an eminent mathematician. But both of theſe gentlemen had done it by means of the quadrature of a curve conſtructed from the paraboloid after the manner of Dr Barrow, *Lect. Geom.* XI. Nor was this a ſolitary diſcovery in the hands of Mr Huyghens, as the rectification of the cycloid had been in thoſe of Sir Chriſtopher Wren; for the method of inveſtigation furniſhed Mr Huyghens with a general rule, by which he could evolve every ſpecies of paraboloid and hyperboloid, two claſſes of curves which come in the way in almoſt every diſcuſſion in the higher geometry. He obſerves, that the ratio of Bf to Ee, being always compounded of the ratios of Bf to Bo, and of Bo, or Dd, to Ee; and the ultimate ratio of Bf to Bo being that of TE to TD, which is given by the nature of the paraboloid, we can always find the ratio of BE to BN, if we know that of Dd to Ee. In all curves, the ratio of Dd to Ee (taken indefinitely near), is that of the ſubtangent to the ſum of the ſubtangent and ordinate of a curve conſtructed on the ſame abſciſſa, having its ordinates equal to the ſubnormals DE, de, VK, &c. In the conic ſections the ratio is conſtant, becauſe the line ſo conſtructed is a ſtraight line; and, in the parabola, it is parallel to the axis. See farther properties of it in Barrow's *Lect. Geom.* XI.

From this inveſtigation, Mr Huyghens has deduced the following beautiful theorem:

Let a be the parameter of the paraboloid, x its abſciſſa, and y its ordinate; and let the equation be $a^m x^n = y^{m+n}$; let the radius of the evolute meet the tangent through the vertex A in Z. We ſhall always have BN $=\frac{n}{m}$ BE $+\frac{m+n}{m}$ BZ. Thus,

$$\left.\begin{array}{l} \text{If } a\,x = y^2 \\ a^2 x = y^3 \\ a\,x^2 = y^3 \\ a\,x^3 = y^5 \\ a\,x = y^4 \\ \quad\&c. \end{array}\right\} \text{ then BN} = \left\{\begin{array}{l} \text{BE} + 2\,\text{BZ} \\ \frac{1}{2}\,\text{BE} + \frac{3}{2}\,\text{BZ} \\ 2\,\text{BE} + 3\,\text{BZ} \\ 3\,\text{BE} + 4\,\text{BZ} \\ \frac{1}{3}\,\text{BE} + \frac{4}{3}\,\text{BZ} \\ \quad\&c. \end{array}\right.$$

This is an extremely ſimple and perſpicuous method of determining the radius of the evolute, or radius of curvature; and it, at the ſame time, gives us the rectification of many curves. It is plain that every geometrical curve may be thus examined, becauſe the ſubnormals DE, VK are determined; and therefore their differences are determined. Theſe differences are the ſame with the differences of Dd and Ee; and therefore the ratio of Dd to Ee is determined; that is, the ſubſidiary curve now mentioned can always be conſtructed.

There is a ſingular reſult from this rule, which would hardly have been noticed, if the common method for determing BN had alone been employed. The equation of the paraboloid is ſo ſimple, that the increaſe of the ordinates and diminution of curvature ſeem to keep pace together; yet we have ſeen that, in the vertex of the cubical parabola, the curvature is leſs than any circular curvature that can be named. In the legs, the curvature certainly diminiſhes as they extend farther; there muſt therefore be ſome intermediate point where the curvature is the greateſt poſſible. This is diſtinctly pointed out by Mr Huyghens's theorem. The evolute of this paraboloid (having $a^2 x = y^3$) is a curve ONRNQ (fig. 9.) conſiſting of two branches RO, and RQ, which have a common tangent in R; the branch RQ has the axis AE for its aſſymptote. The thread unfolding from OR, its extremity, deſcribes the arch BC, and then, unfolding from RQ, it deſcribes the ſmall arch CB′A. When B′ is extremely near A, the thread has a poſition B′N′E, in which B′N is very nearly $\frac{1}{2}$ BE. At C, if CE be biſected in G, GR is $\frac{1}{2}$ of CZ′. Here CR the radius of curvature is the ſhorteſt poſſible. The evolutes of all paraboloids conſiſt of two ſuch branches, if $m+n$ exceeds 2.

Such

Involution.

Such is the theory of evolution and involution as delivered by Mr Huyghens about the year 1672. It was cultivated by the geometers with ſucceſs. Newton prized it highly, and gave a beautiful ſpecimen of its application to the deſcription, rectification, and quadrature of epicycloids, trochoids, and epicycles of all kinds. But it was eclipſed by the fluxionary geometry of Newton, which included this whole theory in one propoſition, virtually the ſame with Mr Huyghens's, but more comprehenſive in its expreſſion, and much more ſimple in its application. Adopting the unqueſtionable principle of Mr Huyghens, that the evolved thread is the radius of a circle which has the ſame flexures with the curve, the point of the evolute will be obtained by finding the length of the radius of the equicurve circle. The formula for this purpoſe is given in the article Fluxions of the *Encyclopædia Britannica;* but is incorrectly ſtated $= \frac{\overline{a+4}|^{\frac{3}{2}}}{2\sqrt{a}}$, inſtead of $\frac{\overline{a+4x}|^{\frac{3}{2}}}{2\sqrt{a}}$. The theorem alſo from which it is deduced $\left(r = \frac{\dot z^3}{-\dot x \ddot y}\right)$ is incorrectly printed, and is given without any demonſtration, thereby becoming of very little ſervice to the reader. For which reaſon, it is neceſſary to ſupply the defect in this place.

Therefore let $A\,b\,c\,d\,E\,f$ (fig. 10.) be a circle, of which C is the centre, and ACE a diameter; let the points b, c, d, of the circumference be referred to this diameter by the equidiſtant perpendicular ordinates $b\,i$, $c\,g$, $d\,k$; draw the chords $b\,c$, $c\,d$, producing $d\,c$ till it meet the ordinate $b\,i$ in a, produce $c\,g$ to the circle in f, and join $b\,f$, $d\,f$; draw $b\,h$, $c\,m$, perpendicular to the ordinates; then $b\,h$, $c\,m$, $h\,c$, $m\,d$, $b\,c$, $c\,d$, are ultimately proportional to the firſt fluxions of the abſciſſa AE, the ordinate $c\,g$, and the arch $A\,c$; alſo $a\,b$, the difference between $d\,m$ and $c\,h$ is ultimately as the ſecond fluxion of the ordinate. The triangle $a\,b\,c$ is ſimilar to $b\,d\,f$; for the angle $a\,b\,c$ is equal to the alternate angle $b\,c\,f$, which is equal to $b\,d\,f$, ſtanding on the ſame ſegment. The angle $a\,c\,b$ is equal to $b\,f\,d$, ſtanding on the ſegment $b\,c\,d$; therefore the remaining angles $b\,a\,c$ and $d\,b\,f$ are equal; therefore $a\,b : b\,c = b\,d : d\,f = \frac{1}{2}\,b\,d : \frac{1}{2}\,d\,f$. Now let the ordinates $b\,i$ and $d\,k$ continually approach the ordinate $c\,g$, and at laſt unite with it; we ſhall then have $b\,c$ ultimately equal to $\frac{1}{2}\,b\,d$, and $c\,g$ ultimately equal to $\frac{1}{2}\,d\,f$. Therefore, ultimately, $a\,b : b\,c = b\,c : c\,g$, and $c\,g = \frac{b\,c^2}{a\,b}$.

Let u, v, w, repreſent the variable abſciſſa, ordinate, and arch. We have, for the fluxionary expreſſion of the ordinate of the equicurve circle, $v = \frac{\dot w}{-\ddot v}$ ($\ddot v$ muſt have the negative ſign, becauſe, as the arch increaſes, $\dot v$ diminiſhes). In the next place, it is evident that, ultimately, $b\,h : b\,c = c\,g : c\,C$, and $c\,C = \frac{c\,g \times b\,c}{b\,h}$. If r be the radius of the equicurve circle, we have $\dot u : \dot w = v : r$, and $r = \frac{v\,\dot w}{\dot u}$. But we had $v = \frac{\dot w^2}{-\ddot v}$. Subſtitute this in the preſent equation, and we obtain $r = \frac{\dot w^3}{-\dot u\,\ddot v}$. Laſtly, obſerve that $\dot w^2 = \dot u^2 + \dot v^2$, and $\dot w = \sqrt{\dot u^2 + \dot v^2} = \overline{\dot u^2 + \dot v^2}|^{\frac{1}{2}}$. Therefore $\dot w^3 = \overline{\dot u^2 + \dot v^2}|^{\frac{3}{2}}$ and we have $r = \frac{\overline{\dot u^2 + \dot v^2}|^{\frac{3}{2}}}{-\dot u\,\ddot v}$, as the moſt general fluxionary expreſſion of the radius of a circle, in terms of the ſine, coſine, and arch.

When a curve and a circle have the ſame curvature, it is not enough that the firſt fluxions of their abſciſſæ, ordinates, and arches, are the ſame. This would only indicate the poſition of their common tangent. They muſt have the ſame deflection from that tangent. This is always equal to half of the ſecond fluxion of the ordinate. Therefore the circle and curve muſt have the ſame ſecond fluxion of their ordinates. Therefore let $D\,b\,c\,d\,F$ be any curve coinciding with, or oſculated by, the circle $A\,b\,c\,d$. Let its axis be DG, parallel to the diameter AE; and let $c\,n$ be its ordinate. Let $D\,n$ be $= x$, $c\,n = y$, and $b\,c = z$. We have $\dot x$, $\dot y$, $\dot z$, reſpectively equal to $\dot u$, $\dot v$, $\dot w$. Therefore the radius of the oſculating circle is $r = \frac{\dot z^3}{-\dot x\,\ddot y}$, or $r = \frac{\overline{\dot x^2 + \dot y^2}|^{\frac{3}{2}}}{-\dot x\,\ddot y}$ for all curves whatever. (We recommend the careful peruſal of the celebrated 2d corollary of the 10th propoſition of the 2d book of Newton's *Principia*, where the firſt principles of this doctrine are laid down with great acuteneſs.)

Inſtead of ſuppoſing the ordinates equidiſtant, and conſequently $\dot x$ invariable, we might have ſuppoſed the ordinates to increaſe by equal ſteps. In this caſe y would have had no ſecond fluxion. The radius would then be $= \frac{\dot z^3}{\dot y\,\ddot x}$. Or, laſtly, we might ſuppoſe (and this is very uſual) the arch z to increaſe uniformly. In this caſe $r = \frac{\dot z\,\dot y}{\ddot x}$: For becauſe $\dot x^2 + \dot y^2 = \dot z^2$, by taking the fluxion of it, $2\,\dot x\,\ddot x + 2\,\dot y\,\ddot y = 0$, and $\ddot y = \frac{\dot x\,\ddot x}{\dot y}$; and therefore $r = \frac{\dot z^3}{\dot y\,\ddot x - \dot x\,\ddot y}, = \frac{\dot z^3}{\dot y\,\ddot x + \frac{\dot x^2\,\ddot x}{\dot y}}, = \frac{\dot y\,\dot z^3}{\overline{\dot y^2 + \dot x^2} \times \ddot x}, = \frac{\dot y\,\dot z}{\ddot x}$.

Having thus obtained the radius of curvature, and conſequently a point of the evolute, we determine its form by reference to an abſciſs, without much farther trouble: It only requires the drawing $C\,p$ perpendicular to the axis of the propoſed curve, and giving the values of $C\,p$ and $D\,p$. If we ſuppoſe $\dot x$ conſtant, then, $c\,C$ being $= \frac{\dot z^3}{-\dot x\,\ddot y}$, we have $D\,p$ $\left(= D\,n + g\,c, = D\,n + \frac{\dot y}{\dot z} \times c\,C\right) = x + \frac{\dot y\,\dot z^2}{-\dot x\,\ddot y}$; and $p\,C$ $\left(= c\,g - c\,n, = \frac{\dot x}{\dot z} \times c\,C - c\,n\right) = \frac{\dot z^2}{-\ddot y} - y$. But if we ſuppoſe $\dot y$ conſtant; then, $c\,C$ being $= \frac{\dot z^3}{\dot y\,\ddot x}$, we have $D\,p = x + \frac{\dot z^2}{\ddot x}$, and $p\,C = \frac{\dot x\,\dot z^2}{\dot y\,\ddot x} - y$. And if $\dot z$ be conſtant, Involution.

constant, then, cC being $= \frac{\dot{y}\dot{z}}{\ddot{x}}$, we shall have $Dp = x + \frac{\dot{y}^2}{\ddot{x}}$, and $pC = \frac{\dot{x}\dot{y}}{\ddot{x}} - y$.

These formulæ are so many general expressions for determining both the curvature of the proposed curve and the form of its evolute. They also give us the rectification of the evolute; because cC is equal to the evolved arch, or to that arch, together with a constant part, which was a tangent to the evolute at its vertex, in those cases where the involute has a finite curvature at its vertex; as in the common parabola.

Let us take the example of the common parabola, that we may compare the two methods. The equation of this is $ax = y^2$, or $a^{\frac{1}{2}} x^{\frac{1}{2}} = y$. This gives $\dot{y} = \frac{1}{2} a^{\frac{1}{2}} \dot{x} x^{-\frac{1}{2}}, = \frac{a^{\frac{1}{2}}\dot{x}}{2x^{\frac{1}{2}}}$, and (making $\dot{x}$ constant) $\ddot{y} = -\frac{1}{2} \times \frac{1}{2} a^{\frac{1}{2}} \dot{x}^2 x^{-\frac{3}{2}} = \frac{-a^{\frac{1}{2}}\dot{x}^2}{4x^{\frac{3}{2}}}$. Wherefore $\dot{z}\ (= \sqrt{\dot{x}^2 + \dot{y}^2}) = \frac{\dot{x}}{2}\sqrt{\frac{4x+a}{x}}$, and the radius of curvature $\left(= \frac{\dot{z}^3}{-\dot{x}\ddot{y}}\right) = \frac{\overline{a+4x}|^{\frac{3}{2}}}{2\sqrt{a}}$. At the vertex, where $x = 0$, the formula becomes $= \frac{1}{2} a$. Again, $Dp \left(= x + \frac{\dot{y}\dot{z}^2}{-\dot{x}\ddot{y}}\right)$ becomes $\frac{1}{2} a + 3x$; and therefore $Vp = 3x$, = the abscissa of our evolute. Likewise cp, its ordinate, $\left(= \frac{\dot{z}^2}{-\ddot{y}} - y\right) = \frac{4x^{\frac{3}{2}}}{\sqrt{a}}$; and $Cp^2 = \frac{16x^3}{a}$; and $Cp^2 \times a = 16x^3$. But $Vp = 3x$, and $Vp^3 = 27x^3$. Therefore $Cp^2 \times \frac{1}{16}$th $a = x^3$, $= \frac{1}{27}$th Vp^3, and $\frac{27}{16}$ths $a \times Cp^2 = Vp^3$. Therefore the evolute VC is a semicubical parabola, whose parameter is $\frac{27}{16}$ths a, as was shewn by Mr Huyghens. The arch VC is $= \frac{\overline{a+4x}|^{\frac{3}{2}}}{2\sqrt{a}} - \frac{1}{2} a$.

We shall give one other example, which comprehends the whole class of paraboloids. Their general equation is $y = ax^n$. This gives us $\dot{y} = nax^{n-1}\dot{x}$, and $\ddot{y} = n \times \overline{n-1} \times ax^{n-2}\dot{x}^2$; therefore $\dot{z}\ (= \sqrt{\dot{x}^2 + \dot{y}^2}) = \dot{x}\sqrt{1 + n^2a^2x^{2n-2}}$; $Cc \left(= \frac{\dot{z}^3}{-\dot{x}\ddot{y}}\right) = \frac{\overline{1 + n^2a^2x^{2n-2}}|^{\frac{1}{2}}}{-n \times \overline{n-1} \times ax^{n-2}}$; $Dp \left(= x + \frac{\dot{y}\dot{z}^2}{-\ddot{y}\dot{x}}\right) = x - \frac{x + n^2a^2x^{2n-1}}{n-1}$; $Cp \left(= \frac{\dot{z}^2}{\ddot{y}} - y\right) = \frac{1 + \overline{2n-1} \times na^2x^{2n-2}}{-\overline{n-1} \times nax^{n-2}}$; and $DV = -\frac{n^2a^2 0^{2n-1}}{n-1}$.

This last formula expresses the radius of curvature at the vertex D, or the redundant part of the thread, by which it exceeds the arch VC of the evolute. If $n = \frac{1}{2}$, the formula becomes $\frac{a^2}{2}$: but if n be greater than this, VC will be $= 0$; and it if it be less, VC will be infinite. Hence it appears, that the radius of curvature at the vertex of a curve is a finite quantity only in the cases where the first or nascent ordinates are in the subduplicate ratio of their abscissæ. In all other cases, the curvature is incomparable with that of any circle, being either what is called infinite (when n is greater than $\frac{1}{2}$) or nothing (when it is less).

Involution.

We scruple not to say, that the method of Mr Huyghens is more luminous, more pleasing to the imagination of a geometer, than this; and in all the cases which occurred to us in our employment of it, it suggested more ready constructions, with the additional satisfaction of exhibiting, in a continuous train, what the *symbolical* method, proceeding by the fluxionary calculus, only indicates by points. We must also observe, that the subsidiary curve employed by Huyghens, having its ordinates equal to the subnormals of the involute under examination, is the geometrical expression of that function of the involute which gives the second fluxions $\ddot{y}$ and $\ddot{x}$ of the ordinate and abscissa. The young mathematician will find no difficulty in constructing this curve *in every case;* whereas we imagine that he will not find it a light matter to construct the final equations of the symbolic method *almost in any case.* At the same time, the all-comprehending extent of the latter method, and the numberless general theorems which it suggests to the expert analyst, give it a most deserved preference, and make it almost an indispensable instrument for all who would extend our physico-mathematical sciences.

In the employment of the geometry of curve lines, especially in the doctrine of centripetal forces, it is usual to consider the ordinates, not as insisting on a rectilineal abscissa, but as diverging from a centre. This is also the usual way of conceiving all spirals and evolutrixes of curves which include space; in short, all RADIAL curves. The process for finding their evolute, or their radius of curvature, is somewhat different from that hitherto exhibited; but it is more simple. Thus, let GPM (fig. 10.) be the elliptical path of a planet, of which S is the focus. We require PC, the radius of curvature in the point P. Let Pp be a very small arch. Draw the radii SP, Sp, the tangents PT, pt; and draw ST perpendicular to PT, cutting pt in t; and Po perpendicular to Sp. Let the arch GP be $= z$, the radius SP $= y$, and the perpendicular ST $= p$. Then, it is plain, that Pp, op, Tt, are ultimately proportional to $\dot{z}$, $\dot{y}$, $\dot{p}$. The triangles PCp, and Tpt or TPt are also ultimately similar; as also the triangles PST and poP. Therefore, ultimately,

Tt : Pp = PT : PC

also Pp : po = PS : PT

therefore Tt : po = PS : PC, or, $\dot{p} : \dot{y} = y : r$, and $r = \frac{y\dot{y}}{\dot{p}}$; an expression of the radius of curvature, extremely simple, and of easy application.

The logarithmic or equiangular spiral PQR (fig. 6.) affords an easy example of the use of this formula. The angle SPT, which the ordinate makes with the curve, is is everywhere the fame. Therefore let a be our tabular radius, and b the fine of the angle SPT. We have $ST = \frac{by}{a}$; and therefore PC $\left(= \frac{y\dot{y}}{\dot{p}}\right) = \frac{ay\dot{y}}{b\dot{y}} = \frac{ay}{b}$. This is to SP or y in the conftant ratio of a to b, or of SP to ST; that is, ST : SP = SP : PC, the triangles SPT and PCS are fimilar, the angles at P and C equal, and C is a point of an equiangular fpiral $p\,y\,r$ round the centre S.

It is not meant that the conftruction pointed out by this theory of involution, expreffed in its moft general and fimple form, is always the beft for finding the centre of the equicurve circle. Our knowledge of, or attention to, many other properties of the curve under confideration, befides thofe which fimply mark its relation to an abfcefs and ordinate, muft frequently give us better conftructions. But evolution is the natural genefis of a line of varying curvature. Moreover, in the moft important employment of mathematical knowledge, namely, mechanical philofophy, it is well known, that the moft certain and comprehenfive method of folving all intricate problems is by reference of all forces and motions to three co-ordinates perpendicular to each other. Thus, without any intentional fearch, we have already in our hands the very fluxionary quantities employed in this doctrine; and the expreffion which it gives of the radius of curvature requires only a change of terms to make it a mechanical theorem.

Thus have we confidered the two chief queftions of evolution and involution. We have done it with as clofe attention to geometry as poffible, that the reader's mind may become familiar with the *ipfa corpora* while acquiring the elementary knowledge, which is to be employed more expeditioufly afterwards by the help of the fymbolical analyfis. Without fuch ideas in the mind, the occupation is oftentimes as much divefted of thought as that of an expert accountant engaged in complex calculations; the attention is wholly turned to the rules of his art.

It now remains to confider a little the nature of this curvature of which fo much has been faid, and about which fo many obfcure opinions have been entertained. We mentioned, in an early part of this article, the unwarranted ufe of the terms of infinite and infinitefimal magnitude as applicable to curvature, and fhewed its impropriety by the inconfiftences into which it leads mathematicians. Nothing threw fo much light on this fubject as Mr Huyghens's Geometry of Evolution; and we fhould have expected that all difputes would have been ended by it. But this has not been the cafe; and even the moft eminent geometers and metaphyficians, fuch as the Bernoullis and Leibnitz, have given explanations of orders of curvature that can have no exiftence, and explanations of that coalefcence which obtains between a curve line and its equicurve circle, which are not warranted by juft principles.

Thefe errors (for fuch we prefume to think them) arofe from the method employed by the geometers of laft century for obtaining a knowledge of the magnitude and variation of curvature. The fcrupulous geometers of antiquity defpaired of ever being able to compare a curve with a right line. The moderns, although taught by Des Cartes to define the nature of a curve by its equation, allowed that this only enabled them to exhibit a feries of points through which it paffed, and to draw the polygon which connects thefe points, but gave no information concerning the continuous *incurvated* arches, of which the fides of the polygon are the chords. They could not generally draw a tangent to any point, or from any point; but they could draw a chord through any two points. Des Cartes was the firft who could draw a tangent. He contrived it fo, that the equation which expreffes the interfections of the curve with a circle defcribed round a given centre fhould have two equal roots. This indicates the coalefcence of two interfections of the common chord of the circle and the curve. Therefore a perpendicular to the radius fo determined muft touch the curve in the point of their union. This was undoubtedly a great difcorery, and worthy of his genius. It naturally led the way to a much greater difcovery. A circle may cut a curve in more points than two: It may cut a conic fection in four points; all expreffed by one equation, having four roots or folutions. What if three of thefe roots fhould be equal? This not only indicates a clofer union than a mere contact, but alfo gives indication of the flexure of the intervening arch. For, before the union, the interfections were in the arch both of the curve and of the circle; and therefore the diftinction between the union of two and of three interfections muft be of the fame kind with that between a ftraight line and an arch of *this* circle. The flexure of a circle being the fame in every part, it becomes a proper index; and therefore the circle, which is determined by the coalefcence of three interfections, was taken as the meafure of the curvature in that point of the curve, and was called the CIRCLE OF CURVATURE, the EQUICURVE CIRCLE. There is a certain progrefs to this coalefcence which muft be noticed. Let ABD (fig. 4.) be a common parabola, EBF a line touching it in B, and BO a line perpendicular to EBF. Taking fome point O in the other fide of the axis for a centre, a circle may be defcribed which cuts the curve in four points a, b, c, and d. By enlarging the radius, it is plain that the points a and b muft feparate, as alfo the points c and d. Thus, the points b and c approach each other, and at laft coalefce in a point of contact B, with the parabola, and with its tangent. In the mean time, a and d have retired to A and D. If we now bring the centre O nearer to B, the new circle will fall wholly within the laft circle ABD; and therefore both A and D will again approach to each other, and to B, which ftill continues a point of contact. It is plain that A will approach fafter to B than D will do. At length, the centre being in o, the point A coalefces with B, and we obtain a circle ε B δ, touching the curve in B, and cutting it in δ: Confequently the arch B $\varepsilon\,\delta$ is wholly within, and B $\varphi\,\delta$ is wholly without the parabola; and the circle both touches and cuts the parabola in B. Here is certainly a clofer union, at leaft on the fide of a. But perhaps a farther diminution of the circle may bring it clofer on the fide of D. Join B δ. Let a fmaller circle be defcribed, touching the parabola in B, and cutting it in φ. Draw $\varphi\,c$ parallel to δ B. It may be demonftrated that the new circle cuts the parabola in c. Now the arch between c and φ being without the parabola, the arch BC muft be within it; and therefore this circle is within the parabola on both fides of of B, and is more incurvated than the parabola. We have seen, that a circle greater than ϵ B δ is without the parabola on both sides of B; and therefore is less incurvated than the parabola. Therefore the individual circle ϵ B δ is neither more nor less curve than the parabola in the point B. Therefore the circle indicated by the coalescence of three intersections is properly named the equicurve circle; and, since we measure all curvatures by that of a circle, it is *properly* the circle of curvature, and its radius is the radius of curvature.

Had B been the vertex of the axis, every intersection on one side of B would have been similar to an intersection on the other, and there would always have been two pairs of roots that are equal; and therefore when three intersections coalesce, a fourth also coalesces, and the contact is said to be still closer.

What has now been shewn with respect to a conic section is true of every curve. When two intersections coalesce, there is a common tangent; when three coalesce, there is an equal curvature, and no other circle can pass between this circle and the curve. There cannot be a coalescence of four intersections, except when the diameter is perpendicular to the ordinates, and those are bisected by the diameter.

Mr Leibnitz, who valued himself for metaphysical refinement, and never fails to claim superiority in this particular, notices the important distinction between a simple contact and this closer union, in a very well written dissertation, published in the *Acta Eruditorum*, July 1686. He calls the contact of equal curvatures an OSCULATION, and the circle of equal curvature the OSCULATING CIRCLE, and delivers several very judicious remarks with the tone of a master and instructor. He also speaks of different degrees or orders of osculation, each of which is infinitely closer than the other, as a thing not remarked by geometers. But Sir Isaac Newton had done all this before. The first twelve propositions of the *Principia* had been read to the Royal Society several years before, and were in the Registers. The *Principia* had received the imprimatur of the Society in July 1686; but was almost printed before that time. In the Scholium to the 11th Lemma, is contained the whole doctrine of contact and osculation; and in the lemma and its corollaries, is crowded a body of doctrine, which has afforded themes for volumes. The author glances with an eagle's eye over the whole prospect, and points out the prominent parts with the most compressed brevity; but with sufficient precision for marking out the more important objects, and particularly the different orders of curvature. This lemma and its corollaries are continually employed in the twelve propositions already mentioned. In 1671 he had written the first draught of his method of fluxions, where this doctrine is systematically treated; and Mr Collins had a copy of it ever since 1676. It is well known that Leibnitz, when in London, had the free perusal of the Society's records, and information at all times by his correspondence with the secretary Oldenburgh and Mr Collins. His conduct respecting the theorems concerning the elliptical motion of the planets, and the resistance of fluids, leave little room to doubt of his having availed himself in like manner of his opportunity of information on this subject. He gives a much better account of the Newtonian doctrine on this subject than in those other instances, it being more suited to his refining and paradoxical disposition.

In this and another dissertation, he considers more particularly the nature of evolution, and of that osculation which obtains between the evolutrix and the circle described by the evolved radius. He says, that it is equivalent to two simple contacts, each of which is equivalent to two intersections. An osculation produced in the evolution of a curve is therefore equivalent to four intersections. And he advises, with an air of authority, the mathematicians to attend to these remarks, as leading them into the recesses of science. He is mistaken, however; and the listening to him would prevent us from forming a just notion of osculation, and from conceiving with distinctness the singular fact of a circle both touching and cutting a curve in the same point. James Bernoulli lost his friendship, because he presumed to say that the presence of four intersections in an osculation is not warranted by the equation expressing those intersections.

Mr Leibnitz was misled by the way in which he had considered the osculation in the evolution of curves. It merits attention. From any point within the space ADFOA (fig. 1.), two perpendiculars may be drawn to the evolutrix A $b\,d\,f$; and therefore two circles may be described round that point, each touching the curve. Each contact is the union of two intersections. Therefore, as the centre approaches the evolute, the contacts approach each other, and they unite when the centre reaches the evolute. Therefore the osculation of evolution is equivalent to four intersections.

But when two such circles are described round a point s, so as that both may touch the evolutrix A $a\,f$, the point s is in the intersection of one evolved radius with the *prolongation* of another. The contact at the extremity b of the prolonged radius b B is an exterior contact, and the arch of the circle crosses the evolutrix, from without inwards, in some point more remote from A. The contact at the extremity e of the radius $\hat{e}$ E is an interior contact; and if $e\,s$ be greater than the straight line EA, the arch of this circle crosses the curve, from within outwards, in some point nearer to A. Thus each contact is accompanied by an intersection on the side next the other contact, sometimes beyond it, and sometimes between the contacts. As the contacts approach, the intersections also approach, still retaining their characters as intersections, as the contacts still continue contacts. Also the circle next to A crosses from without inwards, and that next to f crosses from within outwards. They retain this character to the last; and when the contacts coalesce, the two circles coalesce over their whole circumference, still, however, crossing the curve in the same direction as before; that is, without the curve on the side of A, and within it on the side of f. The contacts unite as contacts, and the intersections as intersections. Thus it is that the osculating circle both touches and intersects the curve in the same point.

At f the osculation is indeed closer than anywhere else. The variation of curvature is less there than anywhere else, because the radius changes more slowly. It is this circumstance that determines the closeness of contact. If a circle osculates a curve, it has the same curvature. If this curvature does not change in the vicinity of the contact, the curve and circle must coincide; and the deviation of the circle (the curvature of which is everywhere the same) from the curve must proceed entirely from the variation of its curvature.

This,

This, therefore, is the important circumſtance, and is indeed the characteriſtic of the figure as a curve line; and its other properties, by which the poſition of its different parts are determined, may be aſcertained by means of the *variation* of its curvature, as well as by its relation to co-ordinates. Of this we have a remarkable inſtance at this very time. The orbit of the newly diſcovered planet has been aſcertained with tolerable preciſion by means of obſervations made on its motions for three years. In this time it had not deſcribed the 20th part of its orbit; yet the figure of this orbit, the poſition of its tranſverſe axis, the place and time of its perihelion, were all determined within 100dth part of the truth by the *obſerved variation* of its curvature. It therefore merits our attention in the cloſe of this article. We know of no author who has treated the ſubject in ſo inſtructive a manner as Mr M'Laurin has done, by exhibiting the theorem which conſtitutes Newton's 11th lemma in a form which points this out even to the eye (ſee *M'Laurin's Fluxions*, Chap. xi. § 363, &c.). We earneſtly recommend this work to the young geometer, as containing a fund of inſtruction and agreeable exerciſe to the mathematical genius, and as greatly ſuperior in perſpicuity and in ideas which can be treaſured up and recollected, when required, to the greateſt part of the elaborate performances of the eminent analyſts of later times. By expreſſing every thing geometrically, the author furniſhes us with a ſort of picture, which the imagination readily reviews, and which exhibits in a train what mere ſymbols only give us a momentary glimpſe of.

"As, of all right lines which can be drawn through a given point in the arch of a curve, that alone is the tangent which touches the arch ſo cloſely that no right line can paſs between them; ſo, of all circles which touch a curve in a given point, that circle alone has the ſame curvature which touches it ſo cloſely that no circle can paſs between them. It cannot coincide with the arch of the curve; and therefore the above condition is ſufficient for making it equicurve. As the curve ſeparates from the tangent by its flexure or curvature, it ſeparates from the equicurve circle by its *change* of curvature; and as its curvature is greater or leſs according as it ſeparates more or leſs from its tangent, ſo the variation of its curvature is greater or leſs according as it ſeparates more or leſs from its equicurve circle. There can be but one equicurve circle at one point of a curve, otherwiſe any other circle deſcribed between them through that point will paſs between the curve and the equicurve circle.

"When two curves touch each other in ſuch a manner that no circle can paſs between them, they muſt have the ſame curvature; becauſe the arch which touches one of them ſo cloſely that no circle can paſs between them, muſt touch the other in like manner. But circles may touch the curve in this manner, and yet there may be indefinite degrees of more or leſs intimate contact between the curve and its equicurve circle." This is ſhewn by the ingenious author in a ſeries of propoſitions, of which a very ſhort abridgment muſt ſuffice in this place.

Let any curve EMH (fig. 11.), and a circle ERB, touch a right line ET on the ſame ſide at E. Let any right line TK, parallel to the chord EB of the circle, meet the tangent in T, the curve in M, and a curve BKF (which paſſes through B) in K. Then, if $MT \times TK$ be everywhere equal to TE^2, the curvature of EMH in the point E is the ſame as that of the circle ERB; and the contact of EM and ER is ſo much the cloſer the ſmaller the angle is which is contained at B between the curve BKF and the equicurve circle BQE.

Let TK meet the circle in R and Q. Then, becauſe $RT \times TQ = TE^2$, it muſt be $RT \times TQ = MT \times TK$; and $RT : MT = TK : TQ$. The line BKF may have any form. It may croſs the circle BQR in B, as in the figure. It may touch it, or touch EB, &c. Let us firſt conſider what ſituations of the point M correſpond with the poſition of K, in that part of the curve BKF which lies without the circle BRE. Let TK move toward EB, always keeping parallel to it, till it coincide with it, or even paſs it. Then, while the point K deſcribes KB, it is evident that ſince TK is greater than TQ, TM muſt be leſs than TR, and the point M muſt always be found between T and R. The arch ME of the curve muſt be nearer to the tangent than the arch RE of the circle. If any circle be now deſcribed touching TE in E, and cutting off from EB a ſmaller chord than EB, it is clear that the whole of this ſegment muſt be within the ſegment BRE; therefore this ſmaller circle does not paſs between ERB and the curve EMH. But ſince we ſee that the curve lies without the circle, in the vicinity of E, perhaps a greater circle than ERB may paſs between it and the curve. A greater circle, touching at E, muſt cut off a chord greater than EB. Let E r b be ſuch a circle, cutting EB in b, and TQ in q. T q is neceſſarily greater than TQ. For ſince b is beyond B, and the arch BKF lies in the angle QB b, the circle E r q muſt croſs the curve FKB in ſome point; ſuppoſe F. Then while K is found in the arch FB, the point q muſt be beyond K, or T q muſt be greater than TK. Now $Tr \times Tq = TE^2, = TM \times TQ$. Therefore $TM : Tr = Tq : TQ$. Therefore T q being greater than TQ, T r muſt be leſs than TM, and the point r muſt lie without the curve, and the arch E r does not paſs between EMH and the circle ERB. In like manner, on the other ſide of EB, it will appear, that when the curve BK'F falls within the circle which touches EMH in E, and cuts off the chord EB, the arch of the curve correſponding to the arch BK'F', lying within the circle, alſo lies within the circle. For T'K' being leſs than TQ', TM' is greater than TR', and the curve is within the circle. And, by ſimilar reaſoning, it is evident that a circle cutting off a greater chord falls without both the circle ER'B and the curve, and that a circle leſs than ER'B muſt neceſſarily leave ſome part of the curve BK'F' without it; and therefore TK' will be greater than T q', and the correſponding point r' muſt be without the curve. All circles therefore touching TE in E fall without both ER and EM, or within them both, according as they cut off from EB a chord greater or leſs than EB, and no circle can paſs between them when the rectangle $MT \times TK$ is always equal to ET^2, and the focus of the point K paſſes through B; that is, ERB is the equicurve circle at E.

This corroborates the ſeveral remarks that we have made on the circumſtance of a circle touching and cutting a curve in the ſame point. No other circle can be made

Involution. made to pafs between it and the curve, and it therefore has the fame curvature. This may therefore be taken as a fufficient indication of the equicurve circle; the character peculiarly affured to it by the nature of evolution. It muft be noted, however, that the curve is fuppofed to have its concavity in the vicinity of the contact turned all the fame way. For if the contact be in a point of contrary fluxure, even a ftraight line will both touch and cut it in that point.

The reader cannot but remark, that MK is always the chord of a circle touching TE in E, and paffing through m

Let E m be another curve, touching TE in E, fuch that the conjugate curve k B, which always gives T m $\times$ T k = TE^2, alfo paffes through B. Then, by what has now been demonftrated, the two curves EM and E m have the fame equicurve circle ERB, and confequently the fame curvature in E. Then, becaufe the rectangles $RT \times TQ$, $MT \times TK$, and $m T \times T k$, are equal, we have $T m : TM = TK : T k$. Therefore if the arch B k pafs between BK and BQ, the curve E m muft pafs between the curve EM and the circle ER. E m muft therefore have a clofer contact with ER than EM has with it; and the fmaller the angle QBK is which is contained between the curve and its equicurve circle, the clofer is the contact of the curve EM and its equicurve circle ER. Thus the length of the chord EB determines the *magnitude* or degree of curvature at E, when compared with another; and the angle contained between the equicurve circle and the conjugate curve BKF determines the clofenefs of the contact of the curve with its equicurve circle (the angle TEB being fuppofed the fame in both.)

It appears, from the procefs of demonftration, that the curve EMH falls without or within the equicurve circle according as its conjugate curve BKF does. Alfo when BKF cuts BQR, HME alfo cuts it. But if FQB is on the fame fide of QB on both fides of the interfection B, the curve HME is alfo on the fame fide of it on both fides of the contact E. It is alfo very clear, that the contact or approach to coalefcence between the curve and its circle of curvature, is fo much the clofer as the conjugate curve BKF comes nearer to the adjoining arch of this circle. It muft be the clofeft of all when KB touches QB, and it muft be the leaft fo when KB touches EB, or has EB for an affymptote. The fpace QBK is a fort of magnified picture of the fpace MER; and we have a fenfible proportion of TQ to TK as the reprefentation of the proportion of TM to TR, quantities which are frequently evanefcent and infenfible. When QBK is a finite angle, that is, when the tangents of BQ and BK do not coincide, the angle QBK can be meafured. But no rectilineal angle can be contained as an unit in the curvilineal angle MER. They are incommenfurable, or incomparable. Let the curve KB touch the circle QB without cutting it. This angle is equally incomparable with the former QBK; yet it has a counterpart in MER. This muft be incomparable with the former in the fame manner; for there is the fame proportion between the individuals of both pairs. Thus it appears plainly, that there are curvilineal angles incomparable with each other. Yet are they magnitudes of one kind; becaufe the fmalleft rectilineal angle muft certainly contain them both; and one of them contains the other.

But, further, there may be indefinite degrees of this coalefcence or clofenefs of contact between a curve and a circle. The firft degree is when the fame right line touches both. This is a *fimple contact*, and may obtain between any curve and any circle. The next is when EMH and ERB have the fame curvature, and when the conjugate curve FKB interfects the circle QB in any affignable angle. This is an *ofculation*. The third degree of contact, and fecond of ofculation, is when the curve KB touches the circle QB, but not fo as to ofculate. The fourth degree of contact, and third of ofculation, is when KB and QB have the fame curvature or ofculate in the firft degree of ofculation. This gradation of more and more intimate contact, or (more properly fpeaking) of approximation to coalefcence, may be continued without end, "*neque novit natura limitem*," the contact of EM and ER being always two degrees clofer than that of BK and BQ. Moreover, in each of thofe claffes of contact there may be indefinite degrees. Thus, when EM and ER have the fame curvature, the angle QBK admits of indefinite varieties, each of which afcertains a different clofenefs of contact at E. Alfo, though the angle QBK fhould be the fame, the contact at E will be fo much the clofer the greater the chord EB is.

For $TR : TM = TK : TQ$

Therefore $RM : TR = KQ : KT$

Or $RM : KQ = TR : TK$; $= TR \times TQ : TK \times TQ$, $= TE^2 : TK \times TQ$.

Therefore, when TE is given, RM (which is then the meafure of the angle of contact) is proportional to KQ directly, and to the rectangle $TK \times TQ$ inverfely; and when KQ is given, RM is lefs in proportion as $KT \times TQ$ is greater. In the very neighbourhood of E and B, it is plain that $KT \times TQ$ is very nearly equal to EB^2, and therefore ultimately $RM : KQ = ET^2 : EB^2$.

It will greatly affift our conception of this delicate fubject, if we view the origin of thefe degrees of contact as they are generated by the evolution of lines. A thread evolving from a polygon EDCBA (fig. 13.) defcribes with its extremity a a line *e d b c a*, confifting of fucceffive arches of circles united in fimple contacts. If it evolve from any continuous curve CBA, after having evolved from the lines ED, BC, the arch *c b* will be united with the circular arch *d c* by ofculation of the firft degree. If any other curve FC touch this evolute in a fimple contact, and if the two curves FCBA and DCBA are both evolved, they will touch each other in a fimple ofculation in that point where they have the fame radius. If FC touches DC in a fimple ofculation, the evolved curves will touch in an ofculation of the fecond degree; and, in general, the ofculation of the two generated curves is a degree clofer than that of their evolutes; and in each ftate of one of the ofculations, there is an indefinite variety of the other, according to the length of its radius of curvature. All this is very clear; and fhews, that thefe degrees of contact do not indicate degrees of curvature, one of which infinitely exceeds another; for they are all finite.

The reader will do well to remark, that the magnitude, which is the fubject of the above proportions, which is really of the fame kind in them all, and confidered as fufceptible of various degrees and orders of infinitefimals, is not curvature, but lineal extenfion. It is RM, the fubtenfe of the angle of contact MER. It is is the linear ſeparation from the tangent, or from the equicurve circle. It is, however, uſually conſidered as the meaſure of curvature, or the proportions of this line are given as the proportions of the curvature. This is inaccurate; for curvature is unqueſtionably a change of direction only. As this line has generally been the intereſting object in the refined ſtudy of curve lines, eſpecially in the employment of it in the diſcuſſions of mechanical philoſophy, it has attracted the whole attention, and the language is now appropriated to this conſideration. What is called, by the moſt eminent mathematicians, variation of curvature, is, in fact, variation of the ſubtenſe of the angle of contact. But it is neceſſary always to diſtinguiſh them carefully.

Variation of curvature is the remaining object of our attention.

Curvature is uniform in the circle alone. When the curvature of the arch EMH (fig. 11.) decreaſes as we recede from E, the arch, being leſs deflected from its primitive direction ET than the arch ER, muſt ſeparate leſs from the line ET, or muſt fall without the arch ER. The more rapidly its curvature decreaſes, the deſcribing point muſt be left more without the circle. It muſt be the contrary, if its curvature had increaſed from E toward M. It may change its curve equably or unequably. If equably, there muſt be a certain uniform rate, which would have produced the ſame final change of direction in a line of the ſame length, bending it into the uniformly incurvated arch of a circle. It is not ſo obvious how to eſtimate a râte of variation of curvature; and authors of eminence have differed in this eſtimation. Sir Iſaac Newton, who was much intereſted in this diſcuſſion, in his ſtudies on univerſal gravitation, ſeems to have adopted a meaſure which beſt ſuited his own views; and has been followed by the greater number. He gives a very clear conception of what he means, by ſtating what he thinks a caſe of an invariable rate of variation. This is the equiangular ſpiral, all the arches of which, comprehended in equal angles from the centre, are perfectly ſimilar. although continually varying in curvature. He calls this a curve EQUABLY VARIABLE, and makes its rate of variation (eſtimated in that ſenſe in which it is uniform) the meaſure of the rate of variation in all other curves. Let us ſee in what reſpect its variation of curvature is conſtant. It may be deſcribed by the evolution of the ſame ſpiral in another poſition (ſee fig. 6.), and the ratio between the radius of the evolute and that of the evolutrix is always the ſame; or (which amounts to the ſame thing) the arch of the evolutrix bears to the evolved arch of the evolute a conſtant ratio. The curvature of the ſpiral changes more rapidly in the ſame proportion as the ratio of the evolved arch to the arch of the evolutrix generated by it is greater, or as it cuts the radii in a more acute angle. Theſe arches may be infiniteſimal; therefore the fraction $\frac{\text{fluxion of evolute}}{\text{fluxion of evolutrix}}$ expreſſes the rate of the variation of curvature in this ſpiral. Now let *abcd* (fig. 13.) be any other curve, and ABCD its evolute; let p be the centre of curvature at the point B of the evolute, and Bo the evolved arch; draw the radii pB, po, Bm, on; join pm, and draw Bq perpendicuar to pm. It is evident that mn and Bo have the ſame ratio with Bm and Bp; and that theſe two ſmall arches may be conceived as being portions of the ſame equiangular ſpiral (perhaps in another poſition), of which q is the centre; and that p is in the curve of another of the ſame. For $qp : q\mathrm{B} = q\mathrm{B} : q\mathrm{M}, = p\mathrm{B} : \mathrm{B}m$; therefore the ratio of theſe infiniteſimal arches mn and Bo will expreſs the rate of variation in any curve. This is evidently equivalent to ſaying, that the variation of curvature is proportional to the fluxion of the radius of curvature directly, and the fluxion of the curve inverſely. For mn and Bo are ultimately as thoſe fluxions, and $\frac{\mathrm{B}o}{mn}$ is equivalent to $\frac{-\dot{r}}{\dot{z}}$, where z is the arch of the ſpiral, and r the evolved radius of the other. Accordingly, this is the enunciation of the INDEX OF VARIATION given by Newton: (See Newton's Fluxions, Prob. VI. § 3.) Therefore, what Newton calls a uniform variation of curvature, is not an increaſe or diminution by equal arithmetical differences, but by equal proportions of the curvature in every point. The variation of curvature in ſimilar points of ſimilar arches is ſuppoſed to be the ſame.

It is evident that this ratio is the ſame with that of radius to the tangent of the angle pmB, or of 1 to its tabular tangent. The tangent therefore of this angle correſponding to any point of a curve is the meaſure of the variation of curvature in that point. Now it may be ſhewn (and it will appear by and bye), that the fluxion of TK in fig. 11. or the ultimate value of KQ, is always ⅔ds of the fluxion of the radius of curvature. Therefore the tangent of the angle QBK is always ⅔ds of that of pmB; and therefore the angle QBK, which we have ſeen to be an index of the cloſeneſs of contact, is alſo the index of the variation of curvature. (See *M'Laurin*, § 386.)

Sir Iſaac Newton has given ſpecimens of the uſe of this meaſure in a variety of geometrical curves, by means of a general expreſſion of $\frac{\dot{r}}{\dot{z}}$. Thus in the curve ABC (fig. 8.), let AB be $= z$, AD $= x$, DB $= y$, BN $= r$, and BE $= p$; we have $\frac{\mathrm{N}n}{\mathrm{B}b} = \frac{\dot{r}}{\dot{z}}$. Now DB : BE $= y : p, = \mathrm{D}d : \mathrm{B}b, = \dot{x} : \dot{z}$. Therefore $\dot{z} = \frac{p\dot{x}}{y}$, and $\frac{\dot{r}}{\dot{z}} = \frac{y\dot{r}}{p\dot{x}}$. Now, in every curve which we can expreſs by an equatión, we can obtain all theſe quantities p, y, $\dot{r}$, and $\dot{z}$, and can therefore obtain the meaſure of the variation of curvature. It alſo deſerves particular notice, that this inveſtigation of $\frac{\dot{r}}{\dot{z}}$ is equivalent with finding the centre and radius of curvature of the evolute, by which the curve under conſideration is generated; or with finding the centre q (fig. 13.) of an equiangular ſpiral, which will touch our curve in m, its evolute in B, and the evolute of the evolute in p, if put into different poſitions when neceſſary. This leads to very curious ſpeculations, for which, however, we have no room. It has been ſaid, for inſtance, that the curvature at the interſection of a cycloid with its baſe is infinitely greater than that of any circle. If the evolution of the cycloid begin from this point, the curvature of its evolutrix will be infinitely greater ſtill upon the ſame principles; and we ſhall have one infinitely greater than

than this by evolving it. Yet all theſe infinites, multiplied to infinity, are contained in the central point of every equiangular ſpiral! In like manner, there are evolutrixes which coincide with a ſtraight line, and others of infinitely greater rectitude, and ſtill they are curves. Can this have any meaning? And can it be reconciled with the legitimate reaſoning from the ſame principles, that all theſe curvatures and angles of contact are producible by evolution; and that they may be, and certainly are every day deſcribed, by bodies moving in free ſpace, and acted on by accelerating forces directed to different bodies?

The parabola (conical) is the moſt ſimple of all the lines of unequably varying curvature, and becomes a very good ſtandard of compariſon. In the parabola ABC (fig. 8.) let the parameter be $2a$. The equation is then $2ax = y^2$; DE $= a$; p, or BE $= \sqrt{a^2 + y^2}$ DQ $= a + 2x$ (by what was formerly demonſtrated). Moreover, DB : BE = DQ : BN; and BN $= \frac{pa + 2px}{a}$, $= r$. Theſe equations give $2a\dot{x} = 2y\dot{y}$, $= 2p\dot{p}$; and $\frac{a\dot{p} + 2x\dot{p} + 2p\dot{x}}{a} = \dot{r}$ Now making $\dot{x} = 1$, and reducing the equations, we obtain $\dot{y} = \frac{a}{y}$; $\dot{p} = \frac{y\dot{y}}{p}$, $= \frac{a}{p}$; and $\dot{r} = \frac{a\dot{p} + 2x\dot{p} + 2p}{a}$.

With theſe values of $\dot{y}, \dot{p}, \dot{r}$, we obtain a numerical value of $\frac{y\dot{r}}{p}$ moſt readily. Thus in order to obtain the index of variation of curvature in the point where the ordinate at the focus cuts the parabola, make $a = 1$. Then $2x = y^2$; $x = \frac{1}{2}$, $y\ (= \sqrt{2x}) = 1$; $\dot{y}\left(= \frac{a}{y}\right) = 1$; $p\ (= \sqrt{a^2 + y^2}) = \sqrt{2}$; $\dot{p}\left(= \frac{a}{p}\right) = \sqrt{\tfrac{1}{2}}$, and $\dot{r}\left(= \frac{a\dot{p} + 2x\dot{p} + 2p}{a}\right) = \sqrt{2} \times 3$. Therefore $\frac{y\dot{r}}{p} = 3$, $=$ the index of variation in the point B when D is the focus of the parabola; that is to ſay, the fluxion of the radius of curvature is three times the fluxion of the curve.

The index of variation, where the ordinate is equal to the parameter, is had by making $x = 2$. This gives $y = 2$; $\dot{y} = \frac{1}{2}$; $p = \sqrt{5}$; $\dot{p} = \sqrt{\tfrac{1}{5}}$, and $\dot{r} = 3\sqrt{5}$. Wherefore $\frac{y\dot{r}}{p} = 6$, which is the index of variation. Moreover, ſince p and $\dot{r}$ are in a conſtant ratio, it appears that the index of variation of curvature in the parabola is proportional to the ordinate y. It is always $= 6\ \frac{\text{ordinate}}{\text{parameter}}$; and thus, with very little trouble, we can deſcribe the evolute of its evolute, *i. e.* of the ſemicubical parabola.

In like manner, it may be ſhewn that in all the conic ſections $\frac{\dot{r}}{\dot{z}}$ is always proportional to the rectangle of the ordinate DB and the ſubnormal DE, or to DB × DE. In the parabola, whoſe equation is $2ax = y^2$, we have $\frac{\dot{r}}{\dot{z}} = \frac{3y}{a}$. In an ellipſe, whoſe equation is $2ax - bx^2 = y^2$, we have $\frac{\dot{r}}{\dot{z}} = \frac{3 - 3b}{a} \times$ DB × DE, and in the hyperbola, whoſe equation is $2ax + bx^2$, $\frac{\dot{r}}{\dot{z}}$ is $= \frac{2 + 3b}{a} \times$ DB × DE. This ratio, in all the three ſections, is always as the tangent of the angle contained between the diameter and the normal at the point of contact. By this we may compare them with a parabola. In the cycloid at the point E (fig. 5.) $\frac{\dot{r}}{\dot{z}}$ is $=$ tan. ∠ EKM, &c. &c.

All theſe things may be traced in the obſervations made on fig. 11. and 12. When the angle BET is a right angle, the angle KBQ indicates it directly, its tangent being always $= \frac{2\dot{r}}{3\dot{z}}$. It is eaſy alſo to ſee, that when the curve EMH is a parabola, the line BKF is a ſtraight line parallel to ET. It is alſo plain, that by the ſame ſteps that we proved that no circle can paſs between this parabola and its equicurve circle ERB, ſo no other parabola can paſs between them. Indeed the ſame reaſoning will prove that no curve of the ſame kind can paſs between any curve and its oſculating circle. In many caſes, it is more eaſy to reaſon from the curvature of a curve, by comparing it with an equicurve parabola than with an equicurve circle; particularly in treating of the curvilineal motions of bodies in free ſpace, actuated by deflecting forces.

If EMH be an ellipſe or hyperbola, BKF is another ellipſe or hyperbola (*M'Laurin*, § 373).

We have thus endeavoured to introduce our readers into this curious branch of ſpeculative geometry. An introduction is all that can be expected from a work of this kind. We have enlarged on particular points, in proportion as we thought that the notions entertained on the ſubject were inadequate, or even vague and indiſtinct; and we hope that ſome may be incited to acquire clearer conceptions by going to the fountain head. We conclude, by recommending to the young geometer the peruſal of the Fluxions of Sir Iſaac Newton, after he has read M'Laurin's Chapter with care. He will probably be ſurpriſed and delighted with ſeeing the whole compreſſed by a maſter's hand into ſuch narrow compaſs with ſuch beautiful perſpicuity.

JOAN d'Arc, the maid of Orleans, has been variouſly characteriſed; but all now agree, that ſhe was worthy of a better fate than the horrid death ſhe was doomed to die. (See Joan *d'Arc*, *Encycl.*) But did ſhe actually die that death? An ingenious writer in the *Monthly Magazine* has proved, we think, that ſhe did not.

The biſhop of Beauvais (ſays he) is accuſed by all parties of treachery and trick in the conduct of the trial: it was his known propenſity to gain his ends by ſtratagem, craft, manœuvre, fraud, dexterity. He ſeeks out, and brings forward, ſuch teſtimony only as relates to eccleſiaſtical offences, and then hands over the deciſion

Joan, Jones.

fion to the fecular judges, whofe clemency he invokes. Joan fays to him publicly, "You * *promifed* to reftore me to the church, and you deliver me to my enemies." The intention of the bifhop, then, muft have been, that the fecular judges, for want of evidence, fhould fee no offence againft the ftate; as the clerical judges, notwithftanding the evidence, had declined to fee any againft the church. A fatal fentence was, however, pronounced; and the fulfilment of it entrufted to the ecclefiaftical authorities. Immediately after the *auto da fé*, one of the executioners ran to two friars, and faid, "that he had never been fo fhocked at any execution, and that the Englifh had built up † a fcaffolding of plafter (*un echafaud de platre*) fo lofty, that he could not approach the culprit, which muft have caufed her fufferings to be long and horrid." She was therefore, by fome *unufual* contrivance, kept out of the reach and obfervation even of the executioners.

* *Villaret Hiftoire de France*, tom. xv. p. 72.

† *Pafquier Hiftoire d'Orleans*, liv. vi.

Some time after, when public commiferation had fucceeded to a vindictive bigotry, a woman appeared at Metz ‡, who declared herfelf to be Joan of Arc. She was everywhere welcomed with zeal. At Orleans, efpecially, where Joan was well known, fhe was received with the honours due to the liberatrefs of the town. She was acknowledged by both her brothers, Jean and Pierre d'Arc. On their teftimony fhe was married by a gentleman of the houfe of Amboife in 1436. At their folicitation her fentence was annulled in 1456. The Parifians, indeed, long remained incredulous: they muft elfe have punifhed thofe ecclefiaftics, whofe humanity, perhaps, confpired with the bifhop of Beauvais to withdraw her from real execution down a central chimney of brick and mortar; or, as the executioner called it, a fcaffolding of plafter. The king, for the woman feems to have fhunned no confrontation, is ftated to have received her with thefe words: "*Pucelle, m'amie, foyez la tres bien revenue, au nom de Dieu.*" She is then faid to have communicated to him, kneeling, the artifice practifed. Can this woman be an impoftor? Our author thinks not, and appeals to Voltaire, who, in his profe works, feems willing to allow that fhe was not, as is too commonly imagined, one of thofe half infane enthufiafts, employed as tools to work upon the vulgar; whom the one party endeavoured to cry up as a prophetefs, and the other to cry down as a witch; but that fhe was a real heroine, fuperior to vulgar prejudice, and no lefs remarkable by force of mind than for a courage and ftrength unufual in her fex. This opinion is certainly countenanced by her behaviour in adverfity, and during her trial, which was firm without infolence, and exalted without affectation.

‡ *Hiftoire de la Pucelle par l'Abbé Lenglet.* See alfo *Mélanges Curieux Monftrelet*; and the manufcript authorities cited by the continuator of Velly.

JONES (Sir William), who was ftyled by Johnfon the moft enlightened of men, was the fon of William Jones, Efq. one of the laft of thofe genuine mathematicians, admirers, and contemporaries of Newton, who cultivated and improved the fciences in the prefent century. Our author was born on the 28th of September 1746, and received his education at Harrow fchool, under the care of Dr Robert Sumner, whom he has celebrated in an eulogium which will outlaft brafs or marble. We are told that he was a clafs-fellow with Dr Parr, and at a very early age difplayed talents which gave his tutor the moft promifing expectations, and which have fince been amply juftified. From Harrow he was fent to Univerfity college, Oxford, where the rapidity and elegance of his literary acquifitions excited general admiration; while a temper, ardently generous, and morals perfectly irreproachable, procured him teftimonies of the moft valuable efteem. The grateful affection which he always cherifhed for that venerable feat of learning, did as much honour to his fenfibility, as Oxford herfelf has received by enrolling him among the number of her fons.

In the twenty-third year of his age he travelled through France, and refided fome time at Nice, where he employed himfelf very differently from moft other young men who make what is called the tour of Europe. *Man*, and the influence of various forms of *government*, were the principal objects of his inveftigation; and in applying the refult of his inquiries to the ftate of his own country, he mingled the folicitudes of the Patriot with the honeft partialities of an Englifhman.

Mr Jones's firft literary work was a tranflation into French of a Perfian manufcript, entitled "*Hiftoire de Nadir Shah, connu fous le nom de Thahmas Kuli Khan, Empereur de Perfe*," in two vols 4to; the hiftory of which performance we fhall give in his own words: "A great northern monarch, who vifited this country a few years ago, under the name of the Prince of Travendal, brought with him an eaftern manufcript, containing the life of Nadir Shah, the late fovereign of Perfia, which he was defirous of having tranflated in England. The fecretary of ftate, with whom the Danifh minifter had converfed upon the fubject, fent the volume to me, requefting me to give a literal tranflation of it in the French language; but I wholly declined the tafk, alleging for my excufe the length of the book, the drynefs of the fubject, the difficulty of the ftyle, and chiefly my want both of leifure and ability to enter upon an undertaking fo fruitlefs and fo laborious. I mentioned, however, a gentleman, with whom I had not then the pleafure of being acquainted, but who had diftinguifhed himfelf by a tranflation of a Perfian hiftory, and was far abler than myfelf to fatisfy the king of Denmark's expectations. The learned writer, who had other works upon his hands, excufed himfelf on the account of his many engagements; and the application to me was renewed. It was hinted, that my compliance would be of no fmall advantage to me at my entrance into life; that it would procure me fome mark of diftinction which might be pleafing to me; and, above all, that it would be a reflection upon this country, if the king fhould be obliged to carry the manufcript into France. Incited by thefe motives, and principally by the laft of them, unwilling to be thought churlifh or morofe, and eager for the bubble Reputation, I undertook the work, and fent a fpecimen of it to his Danifh Majefty; who returned his approbation of the ftyle and method, but defired that the whole tranflation might be perfectly literal, and the oriental images accurately preferved. The tafk would have been far eafier to me, had I been directed to finifh it in Latin; for the acquifition of a French ftyle was infinitely more tedious; and it was neceffary to have every chapter corrected by a native of France, before it could be offered to the difcerning eye of the public, fince in every language there are certain peculiarities of idiom, Jones. idiom, and nice ſhades of meaning, which a foreigner can never learn to perfection. But the work, how arduous and unpleaſing ſoever, was completed in a year, not without repeated hints from the ſecretary's office that it was expected with great impatience by the Court of Denmark." The tranſlation of the Hiſtory of Nadir Shah was publiſhed in the ſummer of the year 1770, at the expence of the tranſlator; and forty copies upon large paper were ſent to Copenhagen; one of them bound with uncommon elegance for the king himſelf, and the others as preſents to his courtiers *.

Preface to the Hiſtory of Nadir Shah, 1773.

What marks of diſtinction our author received, or what fruits he reaped for his labour, he has not thought proper to diſcloſe; but if any dependence is to be placed on common fame, the reward beſtowed upon him for this laborious taſk conſiſted only in the thanks of his Daniſh Majeſty, and the honour of being enrolled in the Royal Society of Copenhagen. That diſtinction was indeed accompanied with a letter, recommending the learned tranſlator to the patronage of his own ſovereign; but, in the interim, his friend Lord Dartmouth, who was to have delivered it, had reſigned his office of ſecretary of ſtate, and the letter, we are told, was never preſented.

There is reaſon to think, that this early and ſevere diſappointment made a deep impreſſion on his mind, and induced him to renounce the muſes for a time, and to apply himſelf with aſſiduity to the ſtudy of juriſprudence. This we think apparent, from the ſtyle in which he writes of his return from the continent, and of the death of his beloved preceptor Dr Sumner.

"When I left Nice, (ſays he) where I had reſided near ſeven months, and after traverſing almoſt all France, returned to England, I moſt ardently deſired to paſs ſeveral years more in the ſtudy of polite literature; as then, I thought, I might enter into public life, to which my ambition had always prompted me, more mature and prepared: but with this fruit of my leiſure, either fortune, or rather Providence, the diſpoſer of all human events, would not indulge my ſloth; for on a ſudden, I was obliged to quit that very literature to which, from my childhood, I had applied myſelf; and he who had been the encourager and aſſiſtant of my ſtudies, who had inſtructed, taught, formed me ſuch as I was, or if I am any thing at all, Robert Sumner, within a year after my return, was ſnatched away by an untimely death."

In 1771 Mr Jones publiſhed *Diſſertation ſur la Literature Orientale*, 8vo, and this was followed by *Lettre à Monſieur A** Du P***, dans laquelle eſt compris l'Examen de ſa Traduction des Livres attribues à Zoroaſtre*, 8vo. The diſſertation offered a favourable ſpecimen of the author's abilities as a linguiſt and as a critic; and the letter contained a ſpirited vindication of the univerſity of Oxford, from the very ſcurrilous reproaches, in which its incompetency in Oriental literature was aſſerted by the illiberal tranſlator of the ſuppoſed works of the Perſian philoſopher.

In the ſame year he gave to the public, "A Grammar of the Perſian language," 4to, and at the ſame time propoſed to republiſh Meninſki's Dictionary, with improvements from *De Labroſſee's Gazophylacium Linguæ Perſarum*, and to add in their proper place an Appendix ſubjoined to Gehanaguire's Perſic Dictionary. The Grammar has been found extremely uſeful, and has been reprinted ſeveral times; but the deſign of the Dictionary, though an object of even national importance, for want of due encouragement was obliged to be laid aſide.

In 1772 he publiſhed "Poems; conſiſting chiefly of Tranſlations from the Aſiatic Languages. To which are added two Eſſays; 1. On the Poetry of the Eaſtern Nations. 2. On the Arts commonly called Imitative," 8vo, which in 1777 he republiſhed with the addition of ſome Latin Poems, every way worthy of their author. On the 18th June 1773, he took the degree of Maſter of Arts, and the ſame year publiſhed "The Hiſtory of the Life of Nadir Shah, King of Perſia. Extracted from an Eaſtern Manuſcript, which was tranſlated into French by order of his Majeſty the King of Denmark. With an Introduction, containing, 1. A Deſcription of Aſia according to the Oriental Geographers. 2. A ſhort Hiſtory of Perſia from the earlieſt Times to the preſent Century: And an Appendix, conſiſting of an Eſſay on Aſiatic Poetry, and the Hiſtory of the Perſian Language. To which are added Pieces relative to the French Tranſlation," 8vo. Our author having at this period determined to ſtudy the law as a profeſſion, and to relinquiſh every other purſuit, our readers will not be diſpleaſed with the following extract, relating to this reſolution, which concludes the preface to the hiſtory now under conſideration:

"To conclude; if any eſſential miſtakes be detected in this whole performance, the reader will excuſe them, when he reflects upon the great variety of dark and intricate points which are diſcuſſed in it; and if the obſcurity of the ſubject be not a ſufficient plea for the errors which may be diſcovered in the work, let it be conſidered, to uſe the words of Pope in the preface to his juvenile poems, that there are very few things in this collection which were not written under the age of five-and-twenty: moſt of them indeed were compoſed in the intervals of my leiſure in the South of France, before I had applied myſelf to a ſtudy of a very different nature, which it is now my reſolution to make the ſole object of my life. Whatever then be the fate of this production, I ſhall never be tempted to vindicate any part of it which may be thought exceptionable; but ſhall gladly reſign my own opinions, for the ſake of embracing others, which may ſeem more probable; being perſuaded, that nothing is more laudable than the love of truth, nothing more odious than the obſtinacy of perſiſting in error. Nor ſhall I eaſily be induced, when I have diſburdened myſelf of two other pieces which are now in the preſs, to begin any other work of the literary kind; but ſhall confine myſelf wholly to that branch of knowledge in which it is my chief ambition to excel. It is a painful conſideration, that the profeſſion of literature, by far the moſt laborious of any, leads to no real benefit or true glory whatſoever. Poetry, ſcience, letters, when they are not made the ſole buſineſs of life, may become its ornaments in proſperity, and its moſt pleaſing conſolation in a change of fortune; but if a man addicts himſelf entirely to learning, and hopes by that, either to raiſe a family, or to acquire, what ſo many wiſh for, and ſo few ever attain, an honourable retirement in his declining age, he will find, when it is too late, that he has miſtaken his path; that other labours, other ſtudies, are neceſſary; and that unleſs he can aſſert his own independence

 pendence in active life, it will avail him little to be favoured by the learned, esteemed by the eminent, or recommended even by kings. It is true, on the other hand, that no external advantages can make amends for the loss of virtue and integrity, which alone give a perfect comfort to him who possesses them. Let a man, therefore, who wishes to enjoy, what no fortune or honour can bestow, the blessing of self-approbation, aspire to the glory given to Pericles by a celebrated historian, of being acquainted with all useful knowledge, of expressing what he knows with copiousness and freedom, of loving his friends and country, and of disdaining the mean pursuits of lucre and interest: this is the only career on which an honest man ought to enter, or from which he can hope to gain any solid happiness."

The next year he published *Poeseos Asiaticæ Commentariorum Libri Sex, cum Appendice; subjicitur Limon, seu Miscellaneorum Liber*, 8vo; and pursuing his purpose of applying to the study of the law, we hear no more of him from the press (except the new edition of his Poems), until the year 1779. In this interval he was called to the bar, and attended Westminster-hall and the Oxford circuit, where he obtained but little business. He was however appointed a commissioner of bankrupts by Lord Bathurst, who is supposed to have intended to exert his interest to procure his nomination to the bench in the East Indies.

He published in this year, "The speeches of Iseus, in causes concerning the law of succession to property at Athens; with a preparatory discourse, notes critical and historical, and a Commentary, 4to." In this valuable work, the talents of the scholar, the critic, and the lawyer, combine to elucidate a very important part of jurisprudence; for, "though deep researches into the legal antiquities of *Greece* and *Rome* (as he observes in his Commentary) are of greater use to scholars and contemplative persons, than to lawyers and men of business; though Bracton and Lyttleton, Coke and Rolle, are the proper objects of our study; yet the ablest advocates, and wisest judges, have frequently embellished their arguments with learned allusions to antient cases; and such allusions, it must be allowed, are often useful, always ornamental; and, when they are introduced without pedantry, never fail to please." The work was dedicated in a style of respectful gratitude to his patron Lord Bathurst.

In the year 1780, we find our author a candidate to represent in parliament the university of Oxford. He had for some time resided but little in the university, and therefore laboured under some disadvantages; but he did not meanly court the support of any man. In a paper, which was circulated on that occasion, his friends, who were numerous, declare, that they have "neither openly solicited, nor intend openly to solicit, votes for Mr Jones within the University itself, because he will never become the instrument of disturbing the calm seat of the Muses, by consenting to any such solicitation for himself or for any man whatever. His own applications have been, are, and will be, confined to those only who have professed a regard for him, *and who have no votes themselves*: the Masters of Arts in a great university, whose prerogative is cool reason and impartial judgment, must never be placed on a level with the voters of a borough, or the freeholders of a county. Even in proceeding thus far, he does not set the example, but follows it; and his friends would never have printed any paper, if they had not thought themselves justified by the conduct of others.

"For the first and the last time, they beg leave to suggest, that no exertions must be spared by those who either personally or by reputation, approve the character of Mr Jones; into which, both literary and political, as well as moral, his friends desire and demand the strictest scrutiny. For his university he began early to provoke, and possibly to incur, the displeasure of great and powerful men: For his university he entered the lists with a foul-mouthed and arrogant Frenchman, who had attacked Oxford in three large volumes of misrepresentation and scurrility: For his university he resigned, for a whole year, his favourite studies and pursuits, to save Oxford the discredit of not having one of her sons ready to translate a tedious Persian manuscript. To Oxford, in short, he is known to be attached by the strongest possible ties; and only regrets the necessity of absenting himself from the place in which of all others he most delights, until the event of the present competition shall either convince him that he has toiled in vain as a man of letters, or shall confer on him the greatest reward to which he can aspire. The unavoidable disadvantage of being so late proposed, and the respectable support with which he is now honoured, will secure him in all events from the least disgrace." The application was unsuccessful, chiefly because his own college had fixed upon another candidate, from a persuasion that the immediate appointment of Mr Jones to a seat, then vacant on the bench of judges in India, was morally certain.

The riots of that year gave occasion to another publication of our author, entitled, "An Inquiry into the legal Mode of suppressing Riots; with a constitutional Plan of future Defence," 8vo; and in 1781 he published "An Essay on the Law of Bailments," 8vo, a very masterly treatise, which did great honour to his legal abilities. In this last work he inculcates the necessity of deeply exploring the grounds of the common law; and speaking of Blackstone, (he says) "his commentaries are the most correct and beautiful outline that ever was exhibited of any human science; but they alone will no more form a lawyer, than a general map of the world, how accurately and elegantly soever it may be delineated, will make a geographer."

In this year he likewise recalled his muse in an Ode on the nuptials of Lord Viscount Althorpe, who had been his pupil, to Miss Lavinia Bingham. This beautiful little poem is preserved in the European Magazine for January 1785, and we think in other periodical publications.

From many circumstances which might be collected together, it would appear that our author at this juncture did not coincide in opinion with those who had the direction of government, nor did he approve the measures at that period adopted.—With these sentiments he seems to have been selected as a proper person to be introduced as a member of the Constitutional Society. Could he have foreseen the degeneracy of such associations, there is reason to believe that he would have declined what he condescended to accept as an honour; for

Jones. for though an ardent friend to liberty, he was an enemy to theoretical innovation, and declares, in a letter to the fecretary, that by the term conftitution, he underftands, "the great fyftem of public, in contradiction to private and criminal law, which comprifes all thofe articles which Blackftone arranges, in his firft volume, under the rights of perfons, and of which he gives a perfpicuous analyfis. Whatever then relates to the rights of perfons, either abfolute rights, as the enjoyment of liberty, fecurity, and property, or relative, that is, in the public relations of magiftrates and people, makes a part of that majeftic whole, which we properly call the conftitution. This conftitutional or public law is partly unwritten, and grounded upon immemorial ufage, and partly written or enacted by the legiflative power; but the unwritten, or common law, contains the true fpirit of our conftitution: the written has often moft unjuftifiably altered the form of it; the common law is the collected wifdom of many centuries, having been ufed and approved by fucceffive generations; but the ftatutes frequently contain the whims of a few leading men, and fometimes of the mere individuals employed to draw them."

In 1782 he publifhed "The Mahomedan Law of Succeffion to the Property of Inteftates, in Arabic, with a verbal Tranflation and explanatory Notes." 4to.

At length the poft of one of the judges in the Eaft Indies, which had been kept vacant five years, was determined upon being filled up; and our author, on the 4th March 1783, was appointed to that ftation, and on the 20th received the honour of knighthood. On the 8th of April he married Mifs Shipley, eldeft daughter of the Bifhop of St Afaph, and almoft immediately embarked for the Indies. He had previoufly publifhed "The Moallakat; or, Seven Arabian Poems, which were fufpended on the Temple at Mecca, with a tranflation and Arguments," 4to. To this it was intended to add a preliminary difcourfe and notes.—The former to comprife obfervations on the antiquity of the Arabian language and letters; on the dialects and characters of Himyar and Koraifh, with accounts of fome Himyarick poets; on the manners of the Arabs in the age immediately preceding that of Mahomed; on the temple at Mecca, and the Moallakat, or pieces of poetry fufpended on its walls or gate; laftly, on the lives of the Seven Poets, with a critical hiftory of their works, and the various copies or editions of them preferved in Europe, Afia, and Africa. The latter to contain authorities and reafons for the tranflation of controverted paffages; to elucidate all the obfcure couplets, and exhibit or propofe amendments of the text; to direct the reader's attention to particular beauties, or point out remarkable defects; and to throw light on the images, figures, and allufions of the Arabian poets, by citations either from writers of their own country, or from fuch of our European travellers as beft illuftrate the ideas and cuftoms of Eaftern nations. This difcourfe and the notes have not yet appeared. At his departure for the eaftern world, he left, in manufcript, with his brother-in-law the Dean of St Afaph, a little tract, entitled "The Principles of Government, in a Dialogue between a Scholar and a Peafant." This celebrated dialogue being afterwards publifhed by the Dean; and widely circulated by the fociety for conftitutional information, the Dean was profecuted for publifhing a libel, and, if our memory deceives us not, was found guilty. Jones.

Sir William Jones now dropt for ever all concern in party politics, and applied himfelf to purfuits more worthy of his talents. During his voyage to India, he conceived the idea of the Afiatic Society, of which an account has been given under the title SOCIETIES (*Encycl.*), and of whofe refearches five volumes, replete with much curious information, are now before the public. But ardently as his mind was attached to general literature and fcience, he was by no means inattentive to the profeffional duties of his high ftation. He had indeed, to ufe his own expreffion, an "undiffembled fondnefs for the ftudy of jurifprudence *;" and in the character of a judge, difplayed the profound knowledge and irreproachable integrity, which, before his promotion, pervaded his reafonings as a lawyer, and governed his conduct as a man. Unfortunately the intenfe ardour of application, which produced his frequent contributions to the ftock of human knowledge, added to the unfavourable influence of the climate, greatly impaired his health. On this account, after a refidence of about fifteen years in India, he made preparations for returning to England; but death interpofed; and this illuftrious ornament of fcience and virtue was taken from the world on the 27th of April 1794, in the 48th year of his age. "It is to the fhame of fcepticifm (as one of his biographers well obferves), to the encouragement of hope, and to the honour of genius, that this great man was a fincere believer in the doctrines of Chriftianity, and that he was found in his clofet in the attitude of addreffing his prayer to God." We fhall give his character as it was drawn by Sir John Shore, Baronet, (now Lord Teignmouth) in a difcourfe delivered at a meeting of the Afiatic Society, held on the 22d of May 1794.

* *Law of Bailments.*

"His capacity for the acquifition of languages has never been excelled. In Greek and Roman literature, his early proficiency was the fubject of admiration and applaufe; and knowledge of whatever nature, once obtained by him, was ever afterwards progreffive. The more elegant dialects of modern Europe, the French, the Spanifh, and Italian, he fpoke and wrote with the greateft fluency and precifion; and the German and Portuguefe were familiar to him. At an early period of life his application to Oriental literature commenced; he ftudied the Hebrew with eafe and fuccefs; and many of the moft learned Afiatics have the candour to avow, that his knowledge of Arabic and Perfian was as accurate and extenfive as their own; he was alfo converfant in the Turkifh idiom, and the Chinefe had even attracted his notice fo far as to induce him to learn the radical characters of that language, with a view perhaps to farther improvements. It was to be expected, after his arrival in India, that he would eagerly embrace the opportunity of making himfelf mafter of the Sanfcrit; and the moft enlightened profeffors of the doctrines of Brahma confefs with pride, delight, and furprife, that his knowledge of their facred dialect was moft critically correct and profound. The Pandits, who were in the habit of attending him, could not, after his death, fupprefs their tears for his lofs, nor find terms to exprefs their admiration at the wonderful progrefs he had made in their fciences.

"Before the expiration of his twenty-fecond year, he had completed his Commentaries on the Poetry of

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the Afiatics, although a confiderable time afterwards elapfed before their publication; and this work, if no other monument of his labours exifted, would at once furnifh proofs of his confummate fkill in the Oriental dialects, of his proficiency in thofe of Rome and Greece, of tafte and erudition far beyond his years, and of talents and application without example.

" But the judgment of Sir William Jones was too difcerning to confider language in any other light than as the key of fcience, and he would have defpifed the reputation of a mere linguift. Knowledge and truth were the objects of all his ftudies, and his ambition was to be ufeful to mankind; with thefe views he extended his refearches to all languages, nations, and times.

" Such were the motives that induced him to propofe to the government of India, what he juftly denominated a work of national utility and importance, the compilation of a copious Digeft of Hindu and Mahomedan Law, from Sanfcrit and Arabic Originals, with an offer of his fervices to fuperintend the compilation, and with a promife to tranflate it. He had forefeen, previous to his departure from Europe, that without the aid of fuch a work, the wife and benevolent intentions of the legiflature of Great Britain, in leaving to a certain extent the natives of thefe provinces in poffeffion of their own laws, could not be completely fulfilled; and his experience, after a fhort refidence in India, confirmed what his fagacity had anticipated, that without principles to refer to, in a language familiar to the judges of the courts, adjudications amongft the natives muft too often be fubject to an uncertain and erroneous expofition, or wilful mifinterpretation of their laws.

" To the fuperintendance of this work, which was immediately undertaken at his fuggeftion, he affiduoufly devoted thofe hours which he could fpare from his profeffional duties. After tracing the plan of the Digeft, he prefcribed its arrangement and mode of execution, and felected from the moft learned Hindus and Mahomedans fit perfons for the tafk of compiling it: flattered by his attention, and encouraged by his applaufe, the Pandits profecuted their labours with chearful zeal to a fatisfactory conclufion. The Molavees have alfo nearly finifhed their portion of the work; but we muft ever regret, that the promifed tranflation, as well as the meditated preliminary differtation, have been fruftrated by that decree, which fo often intercepts the performance of human purpofes.

" During the courfe of this compilation, and as auxiliary to it, he was led to ftudy the works of Menu, reputed by the Hindus to be the oldeft and holieft of legiflators; and finding them to comprife a fyftem of religious and civil duties, and of law in all its branches, fo comprehenfive and minutely exact, that it might be confidered as the Inftitutes of Hindu Law, he prefented a tranflation of them to the government of Bengal. During the fame period, deeming no labour exceffive or fuperfluous that tended in any refpect to promote the welfare or happinefs of mankind, he gave the public an Englifh verfion of the Arabic Text of the Sirajiyah or Mahomedan Law of Inheritance, with a Commentary. He had already (as has been obferved) publifhed in England a tranflation of a tract on the fame fubject by another Mahomedan lawyer, containing, as his own words exprefs, ' a lively and elegant Epitome of the Law of Inheritance of Zaid.'

" To thefe learned and important works, fo far out of the road of amufement, nothing could have engaged his application but that defire which he ever profeffed, of rendering his knowledge ufeful to his nation, and beneficial to the inhabitants of thefe provinces.

" I fhould fcarcely (continues Lord Teignmouth) think it of importance to mention, that he did not difdain the office of editor of a Sanfcrit and Perfian work, if it did not afford me an opportunity of adding, that the latter was publifhed at his own expence, and was fold for the benefit of infolvent debtors. A fimilar application was made of the produce of Sirajiyah."

But nothing exhibits the large grafp of Sir William Jones's mind in fo ftriking a point of view as a paper in his own hand writing, which came into Lord Teignmouth's poffeffion after his death. It was intitled DESIDERATA, and propofed for inveftigation the following fubjects relating to the eaftern world.

India.—1. The antient geography of India, &c. from the Puranas. 2. A botanical defcription of Indian plants, from the Cofhas, &c. 3. A grammar of the Sanfcrit language, from Panini, &c. 4. A dictionary of the Sanfcrit language, from the 32 original vocabularies and Niructi. 5. On the ancient mufic of the Indians. 6. On the medical fubftances of India, and the Indian art of medicine. 7. On the philofophy of the ancient Indians. 8. A tranflation of the Veda. 9. On ancient Indian geometry, aftronomy, and algebra. 10. A tranflation of the Puranas. 11. A tranflation of the Mahabbara and Ramayan. 12. On the Indian theatre, &c. &c. 13. On the Indian conftellations, with their mythology, from the Puranas. 14. The hiftory of India before the Mahomedan conqueft, from the Sanfcrit Cafhmir Hiftories.

Arabia.—15. The hiftory of Arabia before Mahomed. 16. A tranflation of the Hamafa. 17. A tranflation of Hariri. 18. A tranflation of the Facahatul Khulafa. Of the Cafiah.

Perfia.—19. The hiftory of Perfia, from authorities in Sanfcrit, Arabic, Greek, Turkifh, Perfian ancient and modern, Firdaufi's Khrofrau nama. 20. The five poems of Nizami, tranflated in profe. 21. A dictionary of pure Perfian Je changire.

China.—22. A tranflation of Schi-cing. 23. The text of Can-fu-tfu, verbally tranflated.

Tartary.—24. A hiftory of the Tartar nations, chiefly of the Moguls and Othmans, from the Turkifh and Perfian.

" We are not authorifed (fays his Lordfhip) to conclude, that he had himfelf formed a determination to complete the works which his genius and knowledge had thus fketched; the tafk feems to require a period beyond the probable duration of any human life; but we, who had the happinefs to know Sir William Jones; who were witneffes of his indefatigable perfeverance in the purfuit of knowledge, and of his ardour to accomplifh whatever he deemed important; who faw the extent of his intellectual powers, his wonderful attainments in literature and fcience, and the facility with which all his compofitions were made—cannot doubt, if it had pleafed Providence to protract the date of his exiftence, that he would have ably executed much of what he had fo extenfively planned."

We have already enumerated attainments and works which, from their diverfity and extent, feem far beyond the

Jones. the capacity of the moſt enlarged minds; but the catalogue may yet be augmented. To a proficiency in the languages of Greece, Rome, and Aſia, he added the knowledge of the philoſophy of thoſe countries, and of every thing curious and valuable that had been taught in them. The doctrines of the Academy, the Lyceum, or the portico, were not more familiar to him than the tenets of the Vedas, the myſticiſm of the Sufis, or the religion of the ancient Perſians; and whilſt, with a kindred genius, he peruſed with rapture the heroic, lyric, or moral compoſitions of the moſt renowned poets of Greece, Rome, and Aſia, he could turn with equal delight and knowledge to the ſublime ſpeculations or mathematical calculations of Barrow and Newton. With them alſo he profeſſed his conviction of the truth of the Chriſtian religion; and he juſtly deemed it no inconſiderable advantage, that his reſearches had corroborated the multiplied evidence of Revelation, by confirming the Moſaic account of the primitive world.

In his eighth anniverſary diſcourſe to the Aſiatic Society, he thus expreſſes himſelf: "Theological inquiries are no part of my preſent ſubject; but I cannot refrain from adding, that the collection of tracts which we call, from their excellence, the Scriptures, contain, independently of a divine origin, more true ſublimity, more exquiſite beauty, purer morality, more important hiſtory, and finer ſtrains both of poetry and eloquence, than could be collected within the ſame compaſs from all other books that were ever compoſed in any age, or any idiom. The two parts, of which the Scriptures conſiſt, are connected by a chain of compoſitions, which bear no reſemblance in form or ſtyle to any that can be produced from the ſtores of Grecian, Indian, Perſian, or even Arabian learning; the antiquity of theſe compoſitions no man doubts, and the unſtrained application of them to events long ſubſequent to their publication, is a ſolid ground of belief that they were genuine predictions; and conſequently inſpired.

There were, in truth, few ſciences in which he had not acquired conſiderable proficiency; in moſt, his knowledge was profound. The theory of muſic was familiar to him; nor had he neglected to make himſelf acquainted with the intereſting diſcoveries lately made in chemiſtry; "and I have heard him (ſays Lord Teignmouth) aſſert, that his admiration of the ſtructure of the human frame had induced him to attend for a ſeaſon to a courſe of anatomical lectures, delivered by his friend the celebrated Hunter."

His laſt and favourite purſuit was the ſtudy of botany, which he originally began under the confinement of a ſevere and lingering diſorder, which with moſt minds would have proved a diſqualification from any application. It conſtituted the principal amuſement of his leiſure hours. In the arrangements of Linnæus, he diſcovered ſyſtem, truth, and ſcience, which never failed to captivate and engage his attention; and from the proofs which he has exhibited of his progreſs in botany, we may conclude that he would have extended the diſcoveries in that ſcience.

It cannot be deemed uſeleſs or ſuperfluous to inquire by what arts or method he was enabled to attain to a degree of knowledge almoſt univerſal, and apparently beyond the powers of man, during a life little exceeding 47 years.

The faculties of his mind, by nature vigorous, were improved by conſtant exerciſe; and his memory, by habitual practice, had acquired a capacity of retaining whatever had once been impreſſed upon it. To an unextinguiſhed ardour for univerſal knowledge, he joined a perſeverance in the purſuit of it which ſubdued all obſtacles; his ſtudies began with the dawn, and, during the intermiſſions of profeſſional duties, were continued throughout the day; reflection and meditation ſtrengthened and confirmed what induſtry and inveſtigation had accumulated. It was a fixed principle with him, from which he never voluntarily deviated, not to be deterred by any difficulties that were ſurmountable from proſecuting to a ſucceſsful termination what he had once deliberately undertaken.

But what appeared more particularly to have enabled him to employ his talents ſo much to his own and the public advantage, was the regular allotment of his time, and a ſcrupulous adherence to the diſtribution which he had fixed; hence all his ſtudies were purſued without interruption or confuſion. He collected information, too, from every quarter; juſtly concluding, that ſomething might be learned from the illiterate, to whom he liſtened with the utmoſt candour and complacency.

Lord Teignmouth, addreſſing himſelf to the Aſiatic Society, ſays, "Of the private and ſocial virtues of our lamented Preſident, our hearts are the beſt records. To you who knew him, it cannot be neceſſary for me to expatiate on the independence of his integrity, his humanity, probity, or benevolence, which every living creature participated; on the affability of his converſation and manners, or his modeſt, unaſſuming deportment: nor need I remark, that he was totally free from pedantry, as well as from arrogance and ſelf-ſufficiency, which ſometimes accompany and diſgrace the greateſt abilities. His preſence was the delight of every ſociety, which his converſation exhilarated and improved; and the public have not only to lament the loſs of his talents and abilities, but that of his example.

"To him, as the founder of our inſtitution, and whilſt he lived its firmeſt ſupport, our reverence is more particularly due. Inſtructed, animated, and encouraged by him, genius was called forth into exertion, and modeſt merit was excited to diſtinguiſh itſelf. Anxious for the reputation of the ſociety, he was indefatigable in his own endeavours to promote it, whilſt he cheerfully aſſiſted thoſe of others. In loſing him, we have not only been deprived of our brighteſt ornament, but of the guide and patron, on whoſe inſtructions, judgement, and candour, we could implicitly rely." Though theſe are the ſentiments, not only of Lord Teignmouth, but, we believe, of every man of letters, we truſt there is ſtill left in Bengal a ſufficient love of letters and of ſcience to carry on the plan which was formed by the genius of Sir William Jones.

JONESIA, is a very handſome middling-ſized ramous tree, found in gardens about Calcutta. In the Sanſcrit it is called *As'óca*, and in the Bengaleſe *Ruſſuck*; but the name Joneſia was given to it by the Aſiatic Society, who conſecrated it to the memory of their firſt preſident Sir Willam Jones. It is thus deſcribed by Dr Roxburgh, a member of that ſociety:

"*Calyx*, two-leaved, corol, one-petalled, piſtil-bearing, baſe of the tube impervious; ſtamens long, aſcending, inſerted into the margin of a glandulous nectaral ring, which crowns the mouth of the tube, the uppermoſt two-

two of which more distant; style declining. *Legume* turgid. *Trunk* erect, though not very straight. *Bark* dark brown, pretty smooth. *Branches* numerous, spreading in every direction, so as to form a most elegant shady head. *Leaves* alternate, abruptly feathered, sessile, generally more than a foot long; when young, pendulous and coloured. *Leaflets* opposite, from four to six pair, the lowermost broad lanced, the upper lanced; smooth, shining, firm, a little waved, from four to eight inches long. *Petiole* common, round, and smooth. *Stipule* axillary, solitary; in fact a process from the base of the common petiole, as in many of the grasses and monandrists, &c. *Umbels* terminal and axillary; between the stipule and branchlet, globular, crowded, subsessile, erect. *Bracts*, a small hearted one under each division of the umbel. *Peduncle* and pedicles smooth, coloured. *Flowers* very numerous, pretty large; when they first expand they are of a beautiful orange colour, gradually changing to red, forming a variety of lovely shades; fragrant during the night. *Calyx* perianth, below two-leaved, leaflets small, nearly opposite, coloured, hearted, bracte-like, marking the termination of the pedicle, or beginning of the tube of the corol. *Corol* one-petalled, funnel-form; tube slightly incurved, firm, and fleshy, tapering towards the base (club funnel-shaped) and there impervious; border four parted; division spreading, suborbicular; margins most slightly woolly: one third the length of the tube. *Nectary*, a stimeniferous and pistiliferous ring crowns the mouth of the tube. *Stamens*, filaments generally seven; and seven must, I think, be the natural number; viz. three on each side, and one below, above a vacancy, as if the place of an eighth filament, and is occupied on its inside by the pistil; they are equal, distinct, ascending from three to four times longer than the border of the corol. *Anthers* uniform, small, incumbent. *Pistil*, germ oblong, pediceled; pedicle inserted into the inside of the nectary, immediately below the vacant space already mentioned; style nearly as long as the stamens, declining; stigma simple. *Pericarp*, legume scimeter-formed, turgid, outside reticulated, otherwise pretty smooth; from six to ten inches long, and about two broad. *Seeds* generally from four to eight, smooth; grey, size of a large chesnut."

The Jonesia flowers at the beginning of the hot season, and its seeds ripen during the rains. The plants and seeds were originally brought to Calcutta from the interior parts of the country, where it is indigenous. *N. B.* Many of the flowers have only the rudiment of a pistil. In Plate XXX. A is a branchlet of the natural size. B, A single flower a little magnified; *a a* the calyx. C, A section of the same, exhibiting four of the stamens, 1 1 1 1 the pistil 2, and how far the tube is perforated. D, A similar section of one of the abortive flowers; 3 is the abortive fistil. E, The ripe legume opening near the base, natural size. *Note*, The space between the *b* and *c* marks the original tube of the coral. F, One of the seeds, natural size. G, The base of the common petiole, with its stipule; *aa*, the petioles of the lower pair of leaflets.

JOURNALS, the title of periodical publications. See *Encyclopædia*. The principal British Journals are: *The History of the Works of the Learned*, begun at London in 1699. *Censura Temporum*, in 1708. About the same time there appeared two new ones; the one under the title of *Memoirs of Literature*, containing little more than an English translation of some articles in the foreign Journals, by M. de la Roche; the other, a collection of loose tracts, entitled, *Bibliotheca Curiosa*, or a Miscellany. These, however, with some others, are now no more, but are succeeded by the *Annual Register*, which began in 1758; the *New Annual Register*, begun in 1780; the *Monthly Review*, which began in the year 1749, and gives a character of all English literary publications, with the most considerable of the foreign ones: the *Critical Review*, which began in 1756, and is nearly on the same plan: as also the *London Review*, by Dr Kenrick, from 1775 to 1780; *Maty's Review*, from Feb. 1782 to Aug. 1786; the *English Review*, begun in Jan. 1783; and the *Analytical Review*, begun in May 1788, dropt in 1798, and revived in 1799, under the title of the *New Analytical Review*; but again dropt after two or three months trial: the *British Critic*, begun in 1792, and still carried on with much spirit and ability: the *Anti-Jacobin Review and Magazine*, commenced in 1798, for the meritorious purpose of counteracting the pernicious tendency of French principles in politics and religion: the *New London Review*, January 1799: *A Journal of Natural Philosophy, Chemistry, and the Arts*, which was begun in 1797 by Mr Nicholson, and has been conducted in such a manner, that it is one of the most valuable works of the kind to be found in any language: the *Philosophical Magazine*, begun in 1798 by Mr Tilloch, and carried on upon much the same plan, and with much the same spirit, as Nicholson's Journal.

Besides these, we have several monthly pamphlets, called *Magazines*, which, together with a chronological series of occurrences, contain letters from correspondents, communicating extraordinary discoveries in nature and art, with controversial pieces on all subjects. Of these, the principal are those called the *Gentleman's Magazine*, which began with the year 1731; the *London Magazine*, which began a few months after, and has lately been discontinued; the *Universal Magazine*, which is nearly of as old a date; the *Scotch Magazine*, which began in 1739, and is still continued; the *European Magazine*; and the *Monthly Magazine*, a miscellany of much information, but not of good principles.

JOYST or JEYST, the second month of the Bengal year.

IRELAND has been so fully described, and its history so amply detailed, in the Encyclopædia, that it is introduced here only to notice its legislative union with Great Britain. Such a measure had been often wished for by the more intelligent Irish, who could not but hope, from a union, advantages to their country similar to those which Scotland had reaped from her union with England; but it was at all times dreaded by the city of Dublin, and by those individuals who preferred the empty and unmeaning sound of national independence to future prosperity. The rebellion, however, which raged in Ireland during the year 1798, and the danger which was then apprehended of its final separation from Britain, and union with France, made the wiser statesmen in both islands think seriously of a legislative union. The measure, after much opposition from the pretended patriots of both countries, who made it a rule to oppose whatever originated with administration, was finally accomplished, and the royal assent given

ven to the act of union on the 2d of July 1800. By that act, the Irish are admitted to a share of all the trade of Great Britain, except such as is confined to chartered companies, and is of course not free to the inhabitants of Britain at large. The Irish commons are represented by a hundred members in the house of commons at Westminster; the Irish peerage, spiritual and temporal, by four bishops and twenty-eight lay-lords, chosen by the bishops and peers of Ireland, to hold their seats for life: and the sovereign is now styled King of the United Kingdom of Great Britain and Ireland; having, with proper dignity, dropt the empty title of King of France. Ireland still retains her own laws and courts of justice, not excepting even the court of chancery; and his majesty is represented in Dublin by a lord lieutenant, as when the two islands were two kingdoms. Ireland is likewise exempted from all concern with the debt of Great Britain contracted before the union; in which respect the terms granted to her are preferable to those which had been granted by England to Scotland; and her contribution to the imperial expences is as 1 to $7\frac{1}{2}$. This article, however, from the probable increase of her trade, might in time prove extravagantly favourable; it is therefore subject to revisal by the imperial parliament in the course of twenty years. There is one singular clause in this act of union, of which the propriety has been questioned by men of the first-rate abilities who were friendly to the measure: Such Irish peers as are not elected into the house of lords may be chosen as representatives of British towns and counties in the house of commons, provided that, while they are members of that house, they relinquish all the privileges of the peerage.

IRON is by much the most useful of all the metals, as has been sufficiently proved under the article IRON, *Encycl.* and under CHEMISTRY in this *Supplement*. The word is again introduced here, because it affords us an opportunity of laying before our readers some valuable observations by Chaptal on the use of the *oxides* of iron in dyeing cotton.

" The oxide of iron has such an affinity for cotton thread, that if the latter be plunged in a saturated solution of iron in any acid whatever, it immediately assumes a chamoy yellow colour, more or less dark, according to the strength of the liquors. It is both a curious and easy experiment, that when cotton is made to pass through a solution of the sulphat of iron, rendered turbid by the oxide which remains suspended in the liquor, it will be sufficient to dip the cotton in the bath to catch the last particle of the oxide, and to restore to the liquor the transparency it has lost. The solution then, which before had a yellowish appearance, becomes more or less green, according as it is more or less charged.

" The colour given to cotton by the oxide of iron becomes darker merely by exposure to the air; and this colour, soft and agreeable when taken from the bath, becomes harsh and ochry by the progressive oxidation of the metal. The colour of the oxide of iron is very fast: it resists not only the air and water, but also alkaline leys, and soap gives it splendour without sensibly diminishing its intensity. It is on account of these properties that the oxide of iron has been introduced into the art of dyeing, and been made a colouring principle of the utmost value.

" In order that the oxide of iron may be conveniently applied to the cotton thread, it is necessary to begin by effecting its solution; and, in this case, acids are employed as the most useful solvents. Dyers almost everywhere make a mystery of the acid which they employ; but it is always the acetous, the sulphuric, the nitric, or the muriatic. Some of them ascribe great differences to the solution of iron by the one or the other acid; but, in general, they give the preference to the acetous. This predilection appears to be founded much less on the difference of the colours that may be communicated by the one or the other salt, than on the different degrees of corrosive power which each exercises on the stuff. That of the sulphat and muriat is so great, that if the stuff be not washed when it comes from the bath, it will certainly be burnt; whereas solutions by the acetous, or any other vegetable acid, are not attended with the like inconvenience.

" Iron appears to be at the same degree of oxydation in the different acids, since it produces the same shade of colour when precipitated; and any acid solvent may be employed indiscriminately, provided the nature of the salt, and the degree of the saturation of the acid, be sufficiently known; for the subsequent operations may be then directed according to this knowledge, and the inconveniences which attend the use of some of these salts may be prevented. This, without doubt, is a great advantage which the man of science enjoys over the mere workman, who is incapable of varying his process according to the nature and state of the salts which he employs.

" 1. If the sulphat of iron, or any other martial salt, be dissolved in water, and cotton be dipped in the liquid, the cotton will assume a chamoy colour, more or less dark according as the solution is more or less charged. The affinity of the cotton to the iron is so great, that it attracts the metal, and takes it in a great measure from the acid by which it was dissoved.

" 2. If the iron of a pretty strong solution be precipitated by an alkaline liquor that shews five or six degrees (by the areometer of Baumé), the result will be a greenish blue magma. The cotton macerated in this precipitate assumes at first an unequal tint of dirty green; but mere exposure to the air makes it in a little time turn yellow, and the shade is very dark.

" It is by such, or almost similar processes, that dyers communicate what is called among workmen an *ochre* or *rust colour*. But these colours are attended with several inconveniences to the artist: 1. Strong shades burn or injure the cloth: 2. This colour is harsh, disagreeable to the eye, and cannot be easily united with the mild colours furnished by vegetables."

To avoid these inconveniences, our author made several attempts, which led him to the following practice: He treads the cotton cold in a solution of the sulphat of iron, marking three degrees; he wrings it carefully, and immediately plunges it in a ley of potash at two degrees, upon which he has previously poured to saturation a solution of the sulphat of alumine: the colour is then brightened, and becomes infinitely more delicate, soft, and agreeable. The sulphat no longer attacks the tissue of the stuff; and after the cotton has been left in the bath for four or five hours, it is taken out to be wrung, washen, and dried. In this manner we may obtain every shade that can be wished, by graduating the strength of the solutions. This simple process, cefs, the theory of which prefents itfelf to the mind of every chemift, has the advantage of furnifhing a colour very agreeable, exceedingly fixed, and, above all, extremely economical. He employs it with great advantage in dyeing nankeens, as it has the property of refifting leys. It becomes brown, however, by the action of aftringents.

M. Chaptal made feveral attempts to combine this yellow with the blue of indigo, in order to obtain a durable green; but as they were all unfuccefsful, he infers that there is not a fufficient affinity between the blue of indigo and the oxides of iron. He found that thefe oxides, on the other hand, combine very eafily with the red of madder, and produce a bright violet or plum colour, the ufe of which is as extenfive as beneficial in the cotton manufactory. But if we fhould confine ourfelves to apply thefe two colours to cotton, without having employed a mordant capable of fixing the latter, the colour would not only remain dull and difagreeable by the impoffibility of brightening it, but it would ftill be attended with the great inconvenience of not refifting leys. We muft begin, then, by preparing the cotton as if to difpofe it for receiving the Adrianople red; and when it has been brought to the operation of galling, it is to be paffed through a folution of iron, more or lefs charged, according to the nature of the violet required: it is then to be carefully wafhed, twice maddered, and brightened in a bath of foap.

When a real velvety rich violet is required, it is not to be paffed through the folution of iron till it has been previoufly galled; the iron is then precipitated in a bluifh oxide, which, combined with the red of madder, gives a moft brilliant purple, more or lefs dark according to the ftrength of the galling and of the ferruginous folution. It is very difficult to obtain an equal colour by this procefs; and in manufactories, an equal violet is confidered as a mafter-piece of art. It is generally believed, that it is only by well-directed manipulations that it is poffible to refolve this problem, of fo much importance in dyeing. But I am convinced (fays our author), that the great caufe of the inequality in this dye is, that the iron depofited on the cotton receives an oxidation merely by expofure to the air, which varies in different parts of it. The threads which are on the outfide of the hank are ftrongly oxidated, while thofe in the infide, removed from the action of the air, experience no change. It thence follows, that the infide of the hank prefents a weak fhade, while the exterior part exhibits a violet almoft black. The means to remedy this inconvenience is, to wafh the cotton when it is taken from the folution of iron, and to expofe it to the madder moift. The colour will become more equal and velvety. The folvents of iron are almoft the fame for this colour as for the yellow colour already mentioned.

The following obfervation may ferve to guide the artift in brightening the violet on his cotton. The red of madder and the oxide of iron depofited on the ftuff determine the violet colour. This colour becomes red or blue, according as either of the principles predominates. The dyer knows by experience how difficult it is to obtain a combination which produces the tone of colour defired, efpecially when it is required to be very full, lively, and durable. This object, however, may be obtained, not only by varying the proportions of the two colouring principles, but alfo by varying the procefs of brightening. The only point is to be acquainted with the two following facts: that the foda deftroys the iron, while the foap, by ftrong ebullition, feizes in preference the red of the madder. Hence it is, that the colour may be inclined to red or blue, according as you brighten with one or the other of thefe mordants. Thus, cotton taken from the madder dye, when wafhed and boiled in the brightening liquor with $\frac{1}{10}$ths of foap, will give a fuperb violet; whereas you will obtain only a plum colour in treating it with foda.

The oxide of iron precipitated on any ftuff unites alfo very advantageoufly with the fawn colour furnifhed by aftringents; and by varying the ftrength of mordants, an infinity of fhades may be produced. In this cafe, it is lefs a combination or folution of principles than the fimple mixture or juxta-pofition of the colouring bodies on the ftuff. By means of a boiling heat, we may combine, in a more intimate manner, the oxide of iron with the aftringent principle; and then it is brought to the ftate of black oxide, as has been obferved by Berthollet. It is poffible alfo to embrown thefe colours, and to give them a variety of tints, from the bright grey to the deep black, by merely paffing the cottons impregnated with the aftringent principle thro' a folution of iron. The oxide is then precipitated itfelf by the principle which is fixed on the ftuff.

An obfervation, which may become of the utmoft value for the art of dyeing, is, that the moft ufual aftringent vegetables all furnifh a yellow colour, which has not much brilliancy, but which has fufficient fixity to be employed with advantage. This yellow colour is brightened in the feries of vegetables, in proportion as the aftringent principle is diminifhed, and the vivacity of the colour is augmented in the fame proportion. It is difficult, then, to obtain yellow colours which are at the fame time durable and brilliant. Thefe two valuable qualities are to each other in an inverfe ratio; but it is poffible to unite the colouring principles in fuch a manner as to combine fplendour with fixity. Green oak bark unites perfectly with yellow weed, and fumach with green citron. It is by this mixture that we may be able to combine with the oxide of iron vegetable colours, the fplendour of which is equal to their durability.

Our author concludes his obfervations with cautioning the dyer againft fubftituting fumach and the bark of the alder tree or oak for gall when dyeing cotton red. "I can fafely affert (fays he), that it is impoffible to employ thefe as fubftitutes, in whatever dofes they may be ufed. The colour is always much paler, poorer, and lefs fixed. I know that the cafe is not the fame in regard to dyeing wool and filk, in which it may be employed with fuccefs; and in giving an account of this difference, I think the caufe of it may be found in the nature of the gall-nuts. 1. The acid which they exclufively contain, as Berthollet has proved, facilitates the decompofition of the foap with which the cottons have been impregnated, and the oil then remains fixed in their tiffue, and in a greater quantity, as well as in a more intimate combination. 2. The gall-nuts, which owe their development to animal bodies, retain a character of animalifation, which they tranfmit to the vegetable ftuff, and by thefe means augment its affinities with the colouring principle of the madder; for it

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is well known of what utility animal ſubſtances are to facilitate this combination. This animaliſation becomes uſeleſs in operating upon woollen or ſilk."

IRRATIONAL Numbers or *Quantities*, are the ſame as *ſurds*, for which ſee Algebra, *Encycl.*

IRREDUCIBLE Case, in algebra, is uſed for that caſe of cubic equations where the root, according to Cardan's rule, appears under an impoſſible or imaginary form, and yet is real.

It is remarkable that this caſe always happens, *viz.* one root, by Cardan's rule, in an impoſſible form, whenever the equation has three real roots, and no impoſſible ones, but at no time elſe.

If we were poſſeſſed of a general rule for accurately extracting the cube root of a binomial radical quantity, it is evident we might reſolve the irreducible caſe generally, which conſiſts of two of ſuch cubic binomial roots. But the labours of the algebraiſts, from Cardan down to the preſent time, have not been able to remove this difficulty. Dr Wallis thought that he had diſcovered ſuch a rule; but, like moſt others, it is merely tentative, and can only ſucceed in certain particular circumſtances.

JUAN de Fuca, a celebrated ſtrait on the north-weſt coaſt of America, was ſurveyed by Captain Vancouvre in the Diſcovery ſloop of war, with a view to aſcertain whether it leads to any communication between the North Pacific and the North Atlantic Oceans. As they advanced within the opening of the ſtrait, their progreſs was greatly retarded by the number of inlets into which the entrance branched in every direction; and moſt of theſe were examined by the boats, which were frequently abſent from the ſhips on this ſervice for ſeveral days together. In the midſt of their labours, they were ſurpriſed by the ſight of two Spaniſh veſſels of war, employed, like themſelves, in ſurveying this inlet, the examination of which had been begun by them in the preceding year. Meaſures of mutual aſſiſtance were concerted between the captains of the two nations for the proſecution of the ſurvey, in which each agreed to communicate to the other their diſcoveries. Not one of the many arms of the inlet, nor of the channels which they explored in this broken part of the coaſt, was found to extend more than 100 miles to the eaſtward of the entrance into the ſtrait. After having ſurveyed the ſouthern coaſt, on which ſide a termination was diſcovered to every opening, by following the continued line of the ſhore, they were led to the northward, and afterward towards the north-weſt, till they came into the open ſea through a different channel from the ſtrait of Juan de Fuca, by which they had commenced this inland navigation.

Thus it appeared, that the land forming the north ſide of that ſtrait is part of an iſland, or of an archipelago, extending nearly 100 leagues in length from S. E. to N. W.; and on the ſide of this land moſt diſtant from the continent is ſituated Nootka Sound. The moſt peculiar circumſtance of this navigation is the extreme depth of water, when contraſted with the narrowneſs of the channels. The veſſels were ſometimes drifted about by the currents during the whole of a night, cloſe to the rocks, without knowing how to help themſelves, on account of the darkneſs, and the depth being much too great to afford them anchorage.

In the courſe of this ſurvey, the voyagers had frequent communications with the natives, whom they met ſometimes in canoes and ſometimes at their villages. In their tranſactions with Europeans, they are deſcribed as "well verſed in the principles of trade, which they carried on in a very fair and honourable manner." In other reſpects they were leſs honeſt. At one village 200 ſea otter ſkins were purchaſed of them by the crews of the veſſels in the courſe of a day; and they had many more to ſell in the ſame place, as alſo ſkins of bears, deer, and other animals. One party of Indians whom they met had the ſkin of a young lioneſs; and theſe ſpoke a language different from that uſed in Nootka Sound. Veniſon was ſometimes brought for ſale; and a piece of copper, not more than a foot ſquare, purchaſed one whole deer and part of another. Among other articles of traffic, two children, ſix or ſeven years of age, were offered for ſale. The commodities moſt prized by the natives were fire-arms, copper, and great coats. Beads and trinkets they would only receive as preſents, and not as articles of exchange. Many of them were poſſeſſed of fire arms. In one part it is related, that after a chief had received ſome preſents, "he, with moſt of his companions, returned to the ſhore; and, on landing, fired ſeveral muſkets, to ſhew, in all probability, with what dexterity they could uſe theſe weapons, to which they ſeemed as familiarized as if they had been accuſtomed to fire-arms from their earlieſt infancy."

The dreſſes of theſe people, beſides ſkins, are a kind of woollen garments; the materials compoſing which are explained in the following extract:

"The dogs belonging to this tribe of Indians were numerous, and much reſembled thoſe of Pomerania, though, in general, ſomewhat larger. They were all ſhorn as cloſe to the ſkin as ſheep are in England; and ſo compact were their fleeces, that large portions could be lifted up by a corner without cauſing any ſeparation. They were compoſed of a mixture of a coarſe kind of wool, with very fine long hair, capable of being ſpun into yarn. This gave Captain Vancouver reaſon to believe, that their woollen clothing might in part be compoſed of this material mixed with a finer kind of wool from ſome other animal, as their garments were all too fine to be manufactured from the coarſe coating of the dog alone."

Of other animals alive, deer only were ſeen in any abundance by our people.

The number of inhabitants computed to be in the largeſt of the villages or towns that were diſcovered, did not exceed 600. Captain Vancouver conjectured the ſmall-pox to be a diſeaſe common and very fatal among them. Many were much marked; and moſt of theſe had loſt their right eye. Their method of diſpoſing of their dead is very ſingular.

"Baſkets were found ſuſpended on high trees, each containing the ſkeleton of a young child; in ſome of which were alſo ſmall ſquare boxes filled with a kind of white paſte, reſembling (ſays our author) ſuch as I had ſeen the natives eat, ſuppoſed to be made of the ſaranne root; ſome of theſe boxes were quite full, others were nearly empty, eaten probably by the mice, ſquirrels, or birds. On the next low point ſouth of our encampment, where the gunners were airing the powder, they met with ſeveral holes in which human bodies were interred, ſlightly covered over, and in different ſtates of decay, Juan, Jugglers.

some appearing to have been very recently deposited. About half a mile to the northward of our tents, where the land is nearly level with high water mark, a few paces within the skirting of the wood, a canoe was found suspended between two trees, in which were three human skeletons.

"On each point of the harbour, which, in honour of a particular friend, I called *Penn's Cove*, was a deserted village; in one of which were found several sepulchres, formed exactly like a centry box. Some of them were open, and contained the skeletons of many young children tied up in baskets: the smaller bones of adults were likewise noticed, but not one of the limb bones could here be found; which gave rise to an opinion, that these, by the living inhabitants of the neighbourhood, were appropriated to useful purposes; such as pointing their arrows, spears, or other weapons."

However honourable these people have been represented in their conduct as traders, it appeared on several occasions that it was unsafe to depend on their good-will alone: and some instances occurred, of their making every preparation for an attack, from which they desisted only on being doubtful of the event; yet immediately on relinquishing their purpose, they would come with the greatest confidence to trade, appearing perfectly regardless of what had before been in agitation. The boats, as already noticed, were frequently at a great distance from the ships; and on such occasions, when large parties of Indians have first seen them, they generally held long conferences among themselves before they approached the boats; probably for the purpose of determining the mode of conduct which they judged it most prudent to observe. Captain Vancouver places the entrance of the strait of Juan de Fuca in 48° 20′ N. Lat. and 124° W. Long.

JUGGLERS are a kind of people whose profession has not been often deemed either respectable or useful. Professor Beckmann, however, has undertaken their defence; and in a long and learned chapter in the third volume of his *History of Inventions*, pleads the cause of the practisers of legerdemain; rope-dancers; persons who place their bodies in positions apparently dangerous; and of those who exhibit feats of uncommnn strength. All these men he places under the general denomination of *Jugglers;* and taking it for granted (surely upon no good grounds) that every useful employment is full, he contends, that there would not be room on the earth for all its present inhabitants did not some of them practise the arts of *Juggling*.

"These arts (says he) are indeed not unprofitable, for they afford a comfortable subsistence to those who practise them; but their gain is acquired by too little labour to be hoarded up; and, in general, these roving people spend on the spot the fruits of their ingenuity; which is an additional reason why their stay in a place should be encouraged. But farther, it often happens, that what ignorant persons first employ, merely as a show, for amusement or deception, is afterwards ennobled by being applied to a more important purpose. The machine with which a Savoyard, by means of shadows, amused children and the populace, was by Liberkühn converted into a solar microscope; and, to give one example more, the art of making ice in summer, or in a heated oven, enables guests, much to the credit of their hostess, to cool the most expensive dishes. The Indian discovers precious stones, and the European, by polishing, gives them a lustre.

Jugglers.

"But, if the arts of juggling served no other end than to amuse the most ignorant of our citizens, it is proper that they should be encouraged for the sake of those who cannot enjoy the more expensive deceptions of an opera. They answer other purposes, however, than that of merely amusing; they convey instruction in the most acceptable manner, and serve as an agreeable antidote to superstition, and to that popular belief in miracles, exorcism, conjuration, sorcery, and witchcraft, from which our ancestors suffered so severely."

Surely this reasoning, as well as the cause in which it is brought forward, is unworthy of the learning of Beckmann It is indeed true, that jugglers spend their money freely, and that their arts afford them the means of subsistence; but it is very seldom, as our author must know, that they subsist either comfortably or innocently. Is it innocent to entice the ignorant and labouring poor, by useless deceptions, to part with their hard-earned pittance to idle vagabonds? or is the life of those vagabonds comfortable, when it is passed amidst scenes of the most grovelling dissipation? Jugglers spend indeed their money, for the most part on the spot where it is gained; but they spend it in drunkenness, and other seducing vices, which corrupt their own morals and the morals of all with whom they associate; and therefore their stay in a place should certainly *not* be encouraged. Could it be proved that the solar microscope would never have been invented, had not a Savoyard juggler contrived a similar machine to amuse children and the rabble, some stress might be laid on the service which such wretches have rendered to science: but where is the man that will suppose the philosophy of Bacon and Newton to rest upon the arts of juggling? or who considers the refinements of science as of equal value with the morals of the people? There is, at the moment in which this article is drawing up, a fellow exhibiting, before the windows of the writer's chamber, the most indecent scenes by means of puppets, and keeping the mob in a constant roar. Is he innocently employed? or will any good man say that there is not room for him in the ar- 1799.
mies which on the Continent are fighting in the cause of God and humanity!

Our author endeavours to strengthen his reasoning by proving, which he does very completely, the antiquity of juggling. "The deception (says he) of breathing out flames, which at present excites, in a particular manner, the astonishment of the ignorant, is very ancient. When the slaves in Sicily, about a century and a half before our æra, made a formidable insurrection, and avanged themselves in a cruel manner for the severities which they had suffered, there was amongst them a Syrian named Eunus, a man of great craft and courage, who, having passed through many scenes of life, had become acquainted with a variety of arts. He pretended to have immediate communication with the gods; was the oracle and leader of his fellow slaves; and, as is usual on such occasions, confirmed his divine mission by miracles. When, heated by enthusiasm, he was desirous of inspiring his followers with courage, he breathed flames or sparks among them from his mouth while he was addressing them. We are told by historians, Jugglers. tians, that for this purpofe he pierced a nut-fhell at both ends, and, having filled it with fome burning fubftance, put it into his mouth and breathed through it.

"This deception at prefent is performed much better. The juggler rolls together fome flax or hemp, fo as to form a ball about the fize of a walnut; fets it on fire; and fuffers it to burn till it is nearly confumed; he then rolls round it, while burning, fome more flax; and by thefe means the fire may be retained in it for a long time. When he wifhes to exhibit, he flips the ball unperceived into his mouth, and breathes through it; which again revives the fire, fo that a number of weak fparks proceed from it; and the performer fuftains no hurt, provided he infpire the air not through the mouth but the noftrils.

"For deceptions with fire the ancients employed alfo naphtha, a liquid mineral oil, which kindles when it only approaches a flame (fee NAPHTHA, *Encycl.*) Galen informs us, that a perfon excited great aftonifhment by extinguifhing a candle and again lighting it, without any other procefs than holding it immediately againft a wall or a ftone. The whole fecret of this confifted in having previoufly rubbed over the wall or ftone with fulphur. But as the author, a few lines before, fpeaks of a mixture of fulphur and naphtha, we have reafon to think that he alludes to the fame here. Plutarch relates how Alexander the Great was aftonifhed and delighted with the fecret effects of naphtha, which were exhibited to him at Ecbatana. The fame author, as well as Pliny, Galen, and others, has already remarked, that the fubftance with which Medea deftroyed Creufa, the daughter of Creon, was nothing elfe than this fine oil. She fent to the unfortunate princefs a drefs befmeared with it, which burft into flames as foon as fhe approached the fire of the altar. The blood of Neffus, in which the drefs of Hercules, which took fire likewife, had been dipped, was undoubtedly naphtha alfo; and this oil muft have been always employed when offerings caught fire in an imperceptible manner.

"In modern times, perfons who could walk over burning coals or red-hot iron, or who could hold red-hot iron in their hands, have often excited wonder. But laying afide the deception fometimes practifed on the fpectators, the whole of this fecret confifts in rendering the fkin of the foles of the feet and hands fo callous and infenfible, that the nerves under them are fecured from all hurt, in the fame manner as by fhoes and gloves. Such callofity will be produced if the fkin is continually compreffed, finged, pricked, or injured in any other manner. Thus do the fingers of the induftrious fempftrefs become horny by being frequently pricked; and the cafe is the fame with the hands of fire-workers, and the feet of thofe who walk bare-footed over fcorching fand.

"In the month of September 1765, when I vifited (fays our author) the copper-works at Aweftad, one of the workmen, for a little drink-money, took fome of the melted copper in his hand, and after fhewing it to us, threw it againft a wall. He then fqueezed the fingers of his horny hand clofe to each other; put it a few minutes under his arm-pit, to make it fweat, as he faid; and, taking it again out, drew it over a ladle filled with melted copper, fome of which he fkimmed off, and moved his hand backwards and forwards, very quickly, by way of oftentation. While I was viewing this performance, I remarked a fmell like that of finged horn or leather, though his hand was not burnt. It is highly probable that people who hold in their hands red hot iron, or who walk upon it, as I faw done at Amfterdam, but at a diftance, make their fkin callous before, in the like manner. This may be accomplifhed by frequently moiftening it with fpirit of vitriol: according to fome, the juice of certain plants will produce the fame effect; and we are affured by others, that the fkin muft be very frequently rubbed, for a long time, with oil, by which means, indeed, leather alfo will become horny*."

* *Haller, Elementa Phyfiolog.*

Our author then proves, in a very learned manner, that all thefe tricks were of high antiquity; that the Hirpi, who lived near Rome, jumped through burning coals; that women were accuftomed to walk over burning coals at Caftabala in Cappadocia, near the temple dedicated to Diana; that the exhibition of balls and cups (fee LEGERDEMAIN, *Encycl.*) is often mentioned in the works of the ancients; that in the third century, one Firmus or Firmius, who endeavoured to make himfelf emperor in Egypt, fuffered a fmith to forge iron on an anvil placed on his breaft; that rope dancers with balancing poles are mentioned by Petronius and others; and that the various feats of horfemanfhip exhibited in our circufes paffed, in the 13th century, from Egypt to the Byzantine court, and thence over all Europe.

JUNGLE, in Bengal, wafte land, or land covered with wood and brambles.

K.

Kaarta. KAARTA, a kingdom in Africa, through which Mr Park paffed in his route from the Gambia to the Niger. He defcribes the country as confifting either of fandy plains or rocky hills; but, from his account, the level part feems to be the moft extenfive. The natives are negroes, of whom many, though converted to the Mahomedan faith, or rather to the ceremonial part of the Mahomedan religion, retain all their ancient fuperftitions, and even drink ftrong liquors. They are called Johers or Jowers, and in Kaarta form a very numerous and powerful tribe. One of thefe men undertook to conduct our author to Kemmoo, the capital of the kingdom, and alarmed him not a little by his fuperftitious ceremonies.

 "We

Kaarta, Kabobiquas

"We had no fooner (fays Mr Park) got into a dark and lonely part of the firft wood, than he made a fign for us to ftop, and taking hold of a hollow piece of bamboo, that hung as an amulet round his neck, whiftled very loud three times. I confefs I was fomewhat ftartled, thinking it was a fignal for fome of his companions to come and attack us; but he affured me that it was done merely with a view to afcertain what fuccefs we were likely to meet with on our prefent journey. He then difmounted, laid his fpear acrofs the road, and having faid a number of fhort prayers, concluded with three loud whiftles; after which he liftened for fome time, as if in expectation of an anfwer, and receiving none, told us we might proceed without fear, for there was no danger."

White men were ftrangers in the kingdom of Kaarta; and the appearance of our author had on fome of the natives the effect which ignorant people, in this country, attribute to ghofts. "I had wandered (fays he) a little from my people, and being uncertain whether they were before or behind me, I haftened to a rifing ground to look about me. As I was proceeding towards this eminence, two negro horfemen, armed with mufkets, came galloping from among the bufhes: on feeing them I made a full ftop; the horfemen did the fame, and all three of us feemed equally furprifed and confounded at this interview. As I approached them their fears increafed, and one of them, after cafting upon me a look of horror, rode off at full fpeed; the other, in a panic of fear, put his hand over his eyes, and continued muttering prayers until his horfe, feemingly without the rider's knowledge, conveyed him flowly after his companion. About a mile to the weftward, they fell in with my attendants, to whom they related a frightful ftory: it feems their fears had dreffed me in the flowing robes of a tremendous fpirit; and one of them affirmed, that when I made my appearance, a cold blaft of wind came pouring down upon him from the fky like fo much cold water."

At Kemmoo our traveller was gracioufly received by the king; who honeftly told him, however, that he could not protect him, being then engaged in war with the king of Bambarra (fee Segó in this *Supplement*); but he gave him a guard to Jarra, the frontier town of the neighbouring kingdom of Ludamar. The origin and iffue of this war between Kaarta and Bambara, of which Mr Park gives a full account, fhews the folly of attempting to liberate the negroes from flavery till civilization and Chriftianity be introduced into Africa. Major Rennel places Kemmoo, the capital of Kaarta, in 14° 15′ N. Lat. and 7° 20′ W. Long.

KABOBIQUAS, a nation in South Africa, who had never feen a white man till 1785, that they were vifited by M. Vaillant. Intimation had been given of his approach by fome of the tribes through whofe country he had previoufly paffed; and every thing that had been faid of his colour, his fufees, and his equipage, bore the character of the moft enthufiaftic exaggeration. The curiofity of the people was wound up to the higheft pitch; and as foon as they faw his company at a diftance, the whole horde quitted the kraal, and ran with eagernefs to meet him. Not being able to believe their eyes in regard to what they faw, they endeavoured to obtain more fatisfaction by touching him. They felt his hair, hands, and almoft every part of his body. His beard, above all, aftonifhed them to an inconceivable degree. More than thirty perfons came in fucceffion, and half unbuttoned his clothes. They all imagined him to be a hairy animal; and fuppofed, without doubt, that his body was covered with hair as long as that on his chin; but finding this not to be the cafe, they were aftonifhed, and confeffed, with the opennefs of favages, that they had never feen the like in any man of their country. The little children, terrified at his appearance, hid themfelves behind their mothers. When he attempted to lay hold of any of them, in order to carefs them, they fent forth loud cries, as a child would do in Europe who fhould fee a negro for the firft time.

Kabobiquas

The grown up people, however, were foon reconciled to his appearance, and even the children were bribed by fmall bits of fugar candy. The chief of the horde fhewed him every mark of attachment. He was a man advanced in life, and of a majeftic figure. He wore a long mantle, which hung from his fhoulders to the ground, and which, formed of four jackal fkins joined together, was bordered at the fides with that of a hyæna. His left hand wanted two joints of the little finger, which, he faid, were amputated in his infancy to cure him of a fevere illnefs.

This cuftom of favages, who, to relieve a man from pain, add new fufferings to his evils, affords a vaft field for reflection. Mr Paterfon, another African traveller, tells us, that he obferved inftances of the fame practice among a horde at the mouth of Orange-river; which is not improbable. However abfurd a cuftom may be, favage tribes, when they are neighbours, may borrow it from each other; but that it fhould be common among the iflanders of the South Sea, who, fince their country was firft inhabited, had never feen ftrangers before Cook and Bougainville, is truly aftonifhing. Our author was very defirous of interrogating minutely the people of the horde on this fubject. He wifhed alfo to propofe fome queftions to them refpecting other cuftoms which appeared fingular; but difficulties increafed the more he advanced into the country. The Kabobiquas fpoke a particular language; and this dialect, though accompanied with the clapping noife of the Hottentots, was underftood only by the Koraquas, who, on account of their vicinity, kept up fome intercourfe with them. The cafe was the fame with the language of the Koraquas, in regard to their neighbours the Nimiquas; and nothing reached our author's ear till it had paffed through four different mouths. The confequence was, that when he afked any thing, the anfwer had frequently no relation to the queftion; and for this inconveniency no remedy could be found.

The fame defire for trinkets to ornament their drefs prevailed among the Kabobiquas as among the other hordes which Vaillant had vifited; and in one day he purchafed 20 oxen for things of that kind of no value. The chief, however, had fet his affections on a razor; and juft when our authur and he were treating about it, a fhot was fired near them, which was inftantly followed by the moft frightful cries. "Rufhing inftantly from my tent (fays M. Vaillant) to inquire what was the caufe of this noife, I faw a Kabobiqua flying as faft as he could from one of my hunters, while, at the diftance of a hundred paces farther, three men were making the moft lamentable clamour, and near them was a young girl lying

Kabobiquas.

lying on the ground. I made a fignal to my hunter to approach me; but the report of the fhot, and the howling of the three men, had already fpread alarm throughout the horde. Some cried out treachery ; others ran to their arms ; and I now imagined that I was about to be maffacred, with my whole company, and that I fhould be obliged to arm them in my defence. My fituation was the more critical, as neither I, nor any perfon in the kraal, knew what was the caufe of this confufion ; and if I had known, how could I have explained it ?

" Under this embarraffment, I took the chief by the hand, and advanced with him towards the horde. Fear was painted in his countenance ; tears began to drop from his eyes ; and he fpoke to me with great vivacity. He imagined, no doubt, that he was betrayed He complained to me, and accufed my people of perfidy ; yet he readily followed me.

" As I was without arms, and prefented myfelf with the chief, I was received with confidence, and my appearance feemed, in fome meafure, to calm their perturbation. My people, who had feen me direct my courfe towards the kraal, haftened thither after me, to protect me ; and their number overawed the multitude. At length the whole myftery was cleared up, and we learned what had occafioned the tumult.

" A Kabobiqua having met one of my hunters, who was returning with his fufee, wifhed to examine it, and begged him to fhew it to him. In handling it, however, he accidentally touched the trigger ; it inftantly went off ; and the favage, frightened by the unexpected explofion, threw down the fufee, and ran away as faft as he could.

" At that time, three men of the horde and a young girl happened unluckily to be ftanding, at the diftance of a hundred paces, in the direction of the piece. The latter received a fingle grain of fhot in the cheek ; and the others a few grains in the legs and thighs. The author of the misfortune confirmed this explanation ; tranquillity was foon reftored ; the favages depofited their arms ; and I was furrounded only by friends as before.

" Nothing remained but to enquire into the ftate of the wounded, and to give them every affiftance in my power. Without lofs of time, therefore, I repaired, ftill accompanied by the chief, to the place where they were. By the way we met the young girl, who was returning from the kraal, bathed in tears. The caufe of her uneafinefs was a grain of lead, which had, however, penetrated fo little, that I forced it out by only preffing the part with my fingers. With regard to the three men, they lay rolling on the ground, howling in a moft frightful manner, and exhibiting every fymptom of defpair.

" I was aftonifhed at their confternation, and could not conceive how men inured to fufferings fhould be fo much affected by a few fmall punctures, the pain of which could have fcarcely drawn tears from an infant. They at length told me the caufe of their wailings. Thefe favages, accuftomed to poifon their arrows, imagined that I had in like manner poifoned the lead with which they were wounded. They had, therefore, given themfelves up as loft, and expected in a few moments to expire."

It was with great difficulty that our author could convince them that they had nothing to fear. He fhewed them in the flefh of his own leg a dozen of fhots of lead ; but they were not fatisfied till one of the moft intelligent of his Hottentots, taking from his fhot-bag a few grains of lead, and fhewing them to the three men, immediately fwallowed them. This conclufive argument produced the defired effect. The cries of the wounded men inftantly ceafed ; ferenity again appeared in their faces ; and their wounds were no more mentioned.

The Kabobiquas have neither the flat nofe nor plump cheeks of the Hottentots. Their fkin alfo has not that baftard colour, which, being neither black nor white, renders them odious to both races ; nor do they befmear their bodies with thofe difgufting fat fubftances, on account of which one cannot approach them without being bedaubed with their filth, or acquiring an offenfive fmell. In ftature they are as tall as the Caffres, and their colour is equally black. Their hair, which is exceedingly fhort, and much curled, is ornamented with fmall copper buttons, arranged with great art and fymmetry. Inftead of that apron made of a jackal's fkin, employed by the Hottentot to cover what modefty bids him conceal, the Kabobiquas ufe a round piece of leather, the edge of which is ornamented with a fmall indented circle of copper, and which is divided into different compartments by rows of glafs beads of various colours, all proceeding from the centre, and diverging towards the circumference, like the rays in our images of the fun.

This kind of veil is made faft to the groin by means of a girdle ; but as it is only four inches in diameter, as it is deranged by the fmalleft movement, and as they give themfelves little uneafinefs refpecting fuch accidents, it is very ill fuited to the purpofe for which it is applied. During the great heats, this fmall and almoft ufelefs apron is the only covering on their bodies. Its being fo readily difplaced, enabled our author to afcertain that they do not practice circumcifion ; but it feemed to fhew alfo, that, in regard to modefty, their ideas are very different from ours.

Though they go thus almoft entirely naked, their manners, inftead of being licentious, are remarkably chafte No females can be more prudent or more referved than their women ; and whether from refinement of coquetry, or the effect of prudence, they do not tattoo their faces like their hufbands and fathers. They do not even follow their example in ornamenting their hair with copper buttons; and they always go barelegged, though moft of them wear fandals.

Their drefs confifts of an apron that reaches only half down the thigh ; a crofs which, paffing under the arm-pits, is tied on the breaft ; and a long mantle like that of the men. The mantle is made of fkins not deprived of the hair ; and the crofs of tanned leather, prepared like that ufed for gloves in Europe.

With regard to glafs beads, they wear them as bracelets. They form them alfo into necklaces, which defcend in different rows to the pit of the ftomach ; and they fufpend from their girdles feveral ftrings of them, which fall down their thighs below the apron.

Thefe ornaments being very durable, the habit of feeing them renders the women almoft indifferent to the pleafure of poffeffing them. Thofe they procured from our author afforded at firft great fatisfaction, on account of their novelty. But when he fhewed them fciffars and

and needles, they gave the preference to these articles; and this choice does honour to the good sense of the Kabobiqua ladies. Like their chief, they set a higher value on utility than ornament.

Before our author's arrival among them, the Kabobiquas were acquainted with the use of tobacco through the means of some of the tribes more contiguous to the Cape. It was, however, a luxury which they could seldom enjoy; and so indifferent were they about it, that if it were not brought to them, they would not go a step to procure it. This indifference, about an article which is eagerly sought for by all the tribes of Hottentots, seemed to shew that there are traits in the character of the Kabobiquas which distinguish them from their southern neighbours. The case was the same as to strong liquors, on which they set no great value; and though there were among them some few individuals disposed to relish them, the greater number absolutely refused them.

"If the contents of my flasks (says Vaillant) gave them little satisfaction, they were, however, much captivated with the flasks themselves. These transparent bottles excited their admiration in the highest degree. They called them *solid water*; for, notwithstanding the heat of the climate, these savages had seen ice on the summits of the mountains by which they are surrounded; and they entertained no doubt that the glass of my flasks was water, which I had rendered solid by magic, and which I prevented their fires from melting. As it was impossible for me to explain this matter, I did not attempt to undeceive them: and besides, with what advantage would it have been attended? I suffered them, therefore, to continue in their error, and contented myself with conferring on them an obligation, by giving them all the empty bottles for which I had no use.

"On their part, they vied with each other in shewing their generosity towards me; and I must indeed allow, that I never saw a nation so disinterested. Every night they brought to my camp a considerable quantity of milk; and they never came to spend the evening with my people, without bringing some sheep to regale them. I have seen many of them give away gratuitously, and without receiving any thing in return, part of their herds and their flocks; and, when I departed, there were many persons in my caravan who possessed both sheep and oxen, which they had received as a pure gift."

With this benevolent disposition, the Kabobiquas have also a martial character. Their weapons are poisoned arrows, and a lance with a long iron point, but different from the assagay of the Hottentots. In battle, their defensive armour consists of two bucklers; the one of a size sufficient to cover the whole body of the combatant; the other much smaller. They are both made of skins exceedingly thick, and proof against arrows.

The courage which the Kabobiquas display in combat is particularly exercised in their hunting excursions, and, above all, against carnivorous animals. Intrepid, however, as it may be to attack the elephant and the rhinoceros, these species of animals are not objects of their vengeance; because, living upon grass and herbs, they have nothing to apprehend from them, either for themselves or their cattle. But the tiger, lion, hyæna, and panther, being enemies of a different kind, they declare against them implacable war, and pursue them without remission.

Of the spoils of these destructive animals they form their bucklers, girdles, sandals, crosses, mantles, &c. They consider it as a mark of honour to wear them; and they set a much higher value upon them than upon the skin of the rhinoceros or of the elephant. If they sometimes hunt the latter, it is only as objects of food; and they employ to catch them those concealed pits, which are the usual snares of the Hottentots: but this method, which requires both patience and labour, is very little suited to a people so brave and enterprising as the Kabobiquas.

As they possess so bold and resolute a character, one might be induced to believe that they are ferocious and intractable. Among all the African nations, however, which our author visited, he never knew one that so much practised obedience and subordination.

The chief here is not, as in other tribes, a principal among his equals; he is a sovereign in the midst of his subjects, a master surrounded by his slaves. A word, a gesture, or a look, is sufficient to procure him obedience. Whatever be his orders, they are never contradicted; and the case is the same in every particular family. What the chief is to the horde, the father is to his children. His commands are absolute; and he exercises regal power at home, while he obeys elsewhere.

Though the tribe was very numerous, the wisdom with which it was ruled, and the good order that prevailed, announced, in the man by whom it was governed, an intelligence superior to that of all the savages our author had before seen; for he had not then visited the Houzouanas. The habitation of this chief was suited to his supreme dignity. It was, indeed, a hut only, like those of his subjects, and, like them, covered with the skins of animals; but it was much larger, as well as more elevated; and around it were six others, occupied by his family, and destined for them alone.

The natural dryness of the country inhabited by the Kabobiquas obliges them to dig wells, for their own use as well as for their cattle; but as the same cause often dries up these wells, they are then forced to remove, and to seek elsewhere a soil more abundant in springs; for Fish-river, though considerable in the rainy season, is often, during the great heats, entirely destitute of water.

The long journeys which these too frequent emigrations compel them to undertake, and the intercourse which they thence have with other nations, must necessarily inspire them with ideas unknown to the settled tribes; and it would not be unnatural to suppose, that to this extension of ideas are they indebted for that superiority of intelligence which elevates them above their neighbours.

Of the religion of the Kabobiquas, our author talks very inconsistently, and like a true philosopher of the French school. "Of all the African nations (says he), they are the only people among whom I found any idea, however confused a one, of the existence of a Deity. I do not know whether it be from their own reflection, or the communications of other tribes, that they have acquired this sublime knowledge, which would alone bring them

Kajaaga. them near to a level with poliſhed nations; but they believe, as far as I have been able to learn from my people, that beyond the ſtars there exiſts a Supreme Being, who made and who governs all things. I muſt, however, obſerve, that on this ſubject their ideas are vague, barren, and unproductive. They have no conception of the future exiſtence of the ſoul, or of rewards and puniſhments in another life; in ſhort, they have neither worſhip, ſacrifices, ceremonies, nor prieſts, and are total ſtrangers to what we call religion."

This is impoſſible. A people believing in a Supreme Being, who made and who governs all things, *may* indeed be without *ſacrifices*, *ceremonies*, and *prieſts*; but ſuch a people cannot avoid *wiſhing*, that the Being who governs all things may protect them. Such a wiſh is a prayer; and ſurely he who prays is no ſtranger to religion. M. Vaillant places the country of the Kabobiquas between 23° and 25° S. Lat. and 16° 25′ and 19° 25′ Long. eaſt from Paris.

KAJAAGA, an African kingdom, called by the French *Gallam*, is bounded on the ſouth-eaſt and ſouth by Bambouk; on the weſt, by Bondou and Foota Torra; and on the north, by the river Senegal. The air and climate (ſays Mr Park) are more pure and ſalubrious than at any of the ſettlements towards the coaſt; the face of the country is everywhere interſperſed with a pleaſing variety of hills and valleys; and the windings of the Senegal river, which deſcends from the rocky hills of the interior, make the ſcenery on its banks very picturesque and beautiful.

The inhabitants are called Serawoollies, or (as the French write it) *Seracolets*. Their complexion is a jet black: they are not to be diſtinguiſhed in this reſpect from the Jaloffs.

The government is monarchical; and the regal authority, from what I experienced of it, ſeems to be ſufficiently formidable. The people themſelves, however, complain of no oppreſſion; and ſeemed all very anxious to ſupport the king in a conteſt he was going to enter into with the ſovereign of Kaſſon. The Serawoollies are habitually a trading people; they formerly carried on a great commerce with the French in gold and ſlaves, and ſtill maintain ſome traffic in ſlaves with the Britiſh factories on the Gambia. They are reckoned tolerably fair and juſt in their dealings, but are indefatigable in their exertions to acquire wealth, and they derive conſiderable profits by the ſale of ſalt and cotton cloth in diſtant countries. When a Serawoolli merchant returns home from a trading expedition, the neighbours immediately aſſemble to congratulate him upon his arrival. On theſe occaſions the traveller diſplays his wealth and liberality, by making a few preſents to his friends; but if he has been unſucceſsful, his levee is ſoon over; and every one looks upon him as a man of no underſtanding, who could perform a long journey, and (as they expreſs it) *bring back nothing but the hair upon his head.*

Their language abounds much in gutturals, and is not ſo harmonious as that ſpoken by the Foulahs: it is, however, well worth acquiring by thoſe who travel through this part of the African continent; it being very generally underſtood in the kingdoms of Kaſſon, Kaarta, Ludamar, and the northern parts of Bambara. In all theſe countries the Serawoollies are the chief traders.

Joag, the frontier town of this kingdom as you enter it from Piſania, may be ſuppoſed, on a groſs computation, to contain two thouſand inhabitants. It is ſurrounded by a high wall, in which are a number of port holes, for muſquetry to fire through in caſe of an attack. Every man's poſſeſſion is likewiſe ſurrounded by a wall; the whole forming ſo many diſtinct citadels; and amongſt a people unacquainted with the uſe of artillery, theſe walls anſwer all the purpoſes of ſtronger fortifications. To the weſtward of the town is a ſmall river, on the banks of which the natives raiſe great plenty of tobacco and onions. Mr Park was in this town plundered of half his effects by order of the king, becauſe forſooth he had neglected to pay the accuſtomed duties before he entered the kingdom; and it required a good deal of addreſs to prevent himſelf and his attendants from being made ſlaves; a ſtate to which the law, it was ſaid, condemned them for the commiſſion of this unintended crime. He was at laſt reſcued from Joag by a nephew of the king of Kaſſon. Joag is placed by Major Rennel in 14° 25′ N. Lat. and 9° 46′ W. Long.

Kainſi. KAINSI, is the name given by the Hottentots to a particular ſpecies of antelope, of which, according to Vaillant, no author has yet given a perfect deſcription. It is called by the Dutch *klip-ſpringer*, on account of the eaſe with which it leaps from rock to rock; and indeed of all the antelopes there is no one equal to it in agility. It is about the ſize of a kid of a year old, and of a yellowiſh grey colour; but its hair has this peculiarity, that, inſtead of being round, pliable, and firm, like that of moſt other quadrupeds, it is flat, harſh, and ſo little adherent to the ſkin, that the ſlighteſt friction makes it fall off. Nothing is more eaſy, therefore, than to deprive this animal of its hair: dead or alive it is the ſame; to rub, or even to touch the animal, is ſufficient. Another peculiarity of this ſingular hair is its being extremely fragile; ſo that if you take a tuft of it between your fingers, and twiſt it with the other hand, it will break like the barbs of a feather. This property, however, belongs not excluſively to the hair of the kainſi; for our author ſays he has obſerved it in the hair of other quadrupeds, which in the ſame manner live among the rocks.

This antelope differs from the other ſpecies alſo in the ſhape of the foot, which, inſtead of being pointed like theirs, is rounded at the end; and as it is always accuſtomed, both in leaping and walking, to tread with the point of the hoof, without reſting at all on the heel, it leaves a print diſtinguiſhable from that of any other antelope in Africa. Its fleſh is exquiſitely flavoured, and much ſought after, particularly by the hunters.

The chace of the kainſi is very amuſing. It is true, it is ſcarcely poſſible to hunt it down with dogs, as it ſoon eſcapes them by means of its inconceivable agility, and gets out of their reach on the point of ſome detached rock, where it will remain whole hours ſafe from all purſuit, and ſuſpended, as it were, above the abyſs. But in this ſituation it is excellently placed for the arrow or the ball of the huntſman; who is commonly certain of ſhooting it at pleaſure, though he is not always able to come at it when killed. We ſhall give our author's account of a chace of the kainſi in his own words.

"I was hunting (ſays he) one of theſe animals, when, from the nature of the place, it found itſelf ſo preſſed preffed by my dogs, as to be on the point of being run down and taken. There were apparently no means of efcape; fince before it was a vaft perpendicular rock, by which its courfe was neceffarily ftopped. In this wall, however, which appeared to me perfectly fmooth, was a little ridge, projecting at moft not above *two inches*, which the kainfi quickly perceived, and, leaping upon it, to my great aftonifhment kept itfelf *firm* (A). I imagined that, at any rate, it muft foon tumble down; and my dogs, too, fo fully expected it, that they ran to the bottom of the rock, to be ready to catch it when it fell. To haften its fall, I endeavoured to harafs it, and make it lofe its equilibrium; and for this purpofe I pelted it with ftones. All at once, as if gueffing my defign, it collected its whole ftrength, bounded over my head, and, falling a few paces from me, darted away with the utmoft fpeed. Notwithftanding the rapidity of its flight, it would have been eafy for me to have fhot it; but its leap had fo furprifed and amufed me, that I gave it its life." This was generous, if the ftory be true.

KAMTSCHATKA is inhabited by a people, who are reprefented in the *Encyclopædia* as poffeffing almoft every quality that can difgrace human nature. We think it incumbent upon us to acknowledge, in this place, that a much more favourable picture of them is drawn by La Peroufe who vifited Kamtfchatka in September 1787. The Ruffian governor made the commodore and his officers remark the promifing appearance of feveral fmall fields of potatoes, of which the feed had been brought from Irkoutfk a few years before; and purpofed to adopt mild, though infallible means, of making farmers of the Ruffians, Coffacks, and Kamtfchadales. The fmall-pox in 1769 fwept away three-fourths of the individuals of the latter nation, which is now reduced to lefs than four thoufand perfons, fcattered over the whole of the peninfula; and which will fpeedily difappear altogether, by means of the continual mixture of the Ruffians and Kamtfchadales, who frequently intermarry. A mongrel race, more laborious than the Ruffians, who are only fit for foldiers, and much ftronger, and of a form lefs difgraceful to the hand of nature, than the Kamtfchadales, will fpring from thefe marriages, and fucceed the ancient inhabitants. The natives have already abandoned the *yourts*, in which they ufed to burrow like badgers during the whole of the winter, and where they breathed an air fo foul as to occafion a number of diforders. The moft opulent among them now build *ifbas*, or wooden houfes, in the manner of the Ruffians. They are precifely of the fame form as the cottages of our peafants; are divided into three little rooms; and are warmed by a brick ftove, that keeps up a degree of heat (B) infupportable to perfons unaccuftomed to it. The reft pafs the winter, as well as the fummer, in *balagans*, which are a kind of wooden pigeon-houfes, covered with thatch, and placed upon the top of pofts twelve or thirteen feet high, to which the women as well as the men climb by means of ladders that afford a footing very infecure. But thefe latter buildings will foon difappear; for the Kamtfchadales are of an imitative genius, and adopt almoft all the cuftoms of their conquerors. Already the women wear their hair, and are almoft entirely dreffed in the manner of the Ruffians, whofe language prevails in all the *oftrogs*; a fortunate circumftance, fince each Kamtfchadalian village fpoke a different jargon, the inhabitants of one hamlet not underftanding that of the next. It may be faid in praife of the Ruffians, that though they have eftablifhed a defpotic government in this rude climate, it is tempered by a mildnefs and equity that render its inconveniences unfelt. They have no reproaches of atrocity to make themfelves, like the Spaniards in Mexico and Peru. The taxes they levy on the Kamtfchadales are fo light, that they can only be confidered as a mark of gratitude towards the fovereign, the produce of half a day's hunting acquitting the impofts of a year. It is furprifing to fee in cottages, to all appearance more miferable than thofe of the moft wretched hamlets in our mountainous provinces, a quantity of fpecies in circulation, which appears the more confiderable, becaufe it exifts among fo fmall a number of inhabitants. They confume fo few commodities of Ruffia and China, that the balance of trade is entirely in their favour, and that it is abfolutely neceffary to pay them the difference in rubles. Furs at Kamtfchatka are at a much higher price than at Canton; which proves, that as yet the market of Kiatcha has not felt the advantageous effect of the new channel opened in China.

Our author compares Kamtfchatka, with refpect to climate and foil, to the coaft of Labrador in the vicinity of the Straits of Belle Ifle; but the men, like the animals, are there very different. The Kamtfchadales appeared to him the fame people as thofe of the bay of Caftries, upon the coaft of Tartary. Their mildnefs and their probity are the fame, and their perfons are very little different. They ought then no more to be compared to the Efquimaux Indians, than the fables of Kamtfchatka to the martins of Canada.

The Greek religion has been eftablifhed among the Kamtfchadales without perfecution or violence, and with extraordinary facility. The vicar of Paratounka is the fon of a Kamtfchadale and of a Ruffian woman. He delivers his prayers and catechifm with a tone of feeling very much to the tafte of the aborigines, who reward his cares with offerings and alms, but pay no tythes. The canons of the Greek church permitting priefts to marry, we may conclude that the morals of the country clergymen are fo much the better. "I believe them, however (fays Peroufe), to be very ignorant; and do not fuppofe that for a long time to come they will ftand in need of greater knowledge. The daughter, the wife, and the fifter of the vicar, were the beft dancers of all the women, and appeared to enjoy the beft ftate of health. The worthy prieft knew that we were good Catholics, which procured us an ample afperfion of holy water; and he alfo made us kifs the crofs that was carried by his clerk; thefe ceremonies were performed in the midft of the village. His parfonage houfe was a tent, and his altar in the open air; but his ufual abode is Paratounka, and he only came to St Peter and St Paul's to pay us a vifit."

The

(A) This we think incredible.

(B) Not lefs than thirty degrees of Reaumur's thermometer.

The people of Kamtſchatka have inured themſelves to the extremes of heat and cold. It is well known, that their cuſtom in Europe, as well as in Aſia, is to go into vapour baths, come out covered with perſpiration, and immediately roll themſelves in the ſnow. The *oſtrog* of St Peter had two of theſe public baths, into which our author went before the fires were lighted. They conſiſt of a very low room, in the middle of which is an oven conſtructed of ſtones, without cement, and heated like thoſe intended to bake bread. Its arched roofs is ſurrounded by ſeats one above another like an amphitheatre, for thoſe who wiſh to bathe, ſo that the heat is greater or leſs according as the perſon is placed upon a higher or lower bench. Water thrown upon the top of the roof, when heated red hot by the fire underneath, is converted inſtantly into vapour, and excites the moſt profuſe perſpiration. The Kamtſchatdales have borrowed this cuſtom, as well as many others, from their conquerors; and ere long the primitive character that diſtinguiſhed them ſo ſtrongly from the Ruſſians will be entirely effaced.

Our author deſcribes the bay of Avatſcha as the fineſt, the moſt convenient, and the ſafeſt, that is to be met with in any part of the world. The entrance is narrow, and ſhips would be forced to paſs under the guns of the forts that might be eaſily erected. The bottom is mud, and excellent holding ground. Two vaſt harbours, one on the eaſtern ſide, the other on the weſtern, are capable of containing all the ſhips of the French and Engliſh navy. The rivers of Avatſcha and Paratounka fall into this bay, but they are choaked up with ſand-banks, and can only be entered at the time of high water. The village of St Peter and St Paul is ſituated upon a tongue of land, which, like a jetty made by human art, forms behind the village a little port, ſhut in like an amphitheatre, in which three or four veſſels might lie up for the winter. The entrance of this fort of baſon is more than twenty-five toiſes wide; and nature can afford nothing more ſafe or commodious. On its ſhore the Governor propoſed to lay down the plan of a city, which ſome time or other will be the capital of Kamtſchatka, and perhaps the centre of an extenſive trade with China, Japan, the Phillippines, and America. A vaſt pond of freſh water is ſituated northward of the ſite of this projected city; and at only three hundred toiſes diſtance run a number of ſtreamlets, the eaſy union of which would give the ground all the advantages neceſſary to a great eſtabliſhment. Of theſe advantages Mr Kaſloff underſtood the value; "but firſt (ſaid he a thouſand times over) we muſt have bread and hands, and our ſtock of both of them is very ſmall." He had, however, given orders, which announced a ſpeedy union of the other *oſtrogs* to that of St Peter and St Paul, where it was his intention immediately to build a church. By obſervation, St Peter and St Paul was found to be in 53° 1′ N. Lat. and 156° 30′ E. Long. from Paris.

KANEM, is the name given by Adriſi to the kingdom of Bornou in Africa, of which the reader will find ſome account in the *Encyclopædia Britannica*. In ſome particulars, however, that account is incorrect. The kingdom of Bornou or Kanem muſt extend farther eaſt and farther north than it is there ſaid to do; for according to the lateſt and beſt accounts, its capital ſtands in Lat. 24° 32′, Long. 22° 57′. The empire is ſaid to

be very extenſive; and if it be true, as we learn from the proceedings of the African Aſſociation, that its ſovereign is more powerful than the Emperor of Morocco, the people cannot be ſuch abſolute brutes, as we have repreſented them in the article referred to; for the ſovereign of brutes would have no power. The truth, however is, that very little is yet known in Europe of Bornou or its inhabitants.

KANT (Immanuel), Royal Profeſſor of Morals and Metaphyſics in the Univerſity of Konigſberg, publiſhed ſome years ago a new ſyſtem of Metaphyſics, to which he gave the name of *Critical* Philosophy, which ſee in this *Supplement*.

KANTUFFA, a ſpecies of thorn peculiar to Abyſſinia, is thus deſcribed by Mr Bruce: The branches ſtand two and two upon the ſtalk; the leaves are diſpoſed two and two likewiſe, without any ſingle one at the point, whereas the branches bearing the leaves part from the ſtalk: at the immediate joining of them are two thick thorns placed perpendicular and parallel alternately; but there are alſo ſingle ones diſtributed in all the interſtices throughout the branch.

The male plant has a one-leaved perianthium, divided into five ſegments, and this falls off with the flower. The flower is compoſed of five petals, in the middle of which riſe ten ſtamina or filaments, the outer row ſhorter than thoſe of the middle, with long ſtigmata, having yellow farina upon them. The flowers grow in a branch, generally between three and four inches long, in a conical diſpoſition, that is, broader at the baſe than the point. The inſide of the leaves are a vivid green, in the outſide much lighter. It grows in form of a buſh, with a multitude of ſmall branches riſing immediately from the ground, and is generally ſeven or eight feet high. Our author ſaw it when in flower only, never when bearing fruit. It has a very ſtrong ſmell, reſembling that of the ſmall ſcented flower called mignionet, ſown in vaſes and boxes in windows, or rooms, where flowers are kept.

Our author repreſents the kantuffa as ſo very troubleſome, that it renders travelling through ſome places of Abyſſinia almoſt impoſſible. The ſoldier ſcreens himſelf from it by a goat's, a leopard's, or a lion's ſkin thrown over his ſhoulders, of which it has no hold. As his head is bare, he always cuts his hair ſhort before he goes to battle, leſt his enemy ſhould take advantage of it; but the women, wearing their hair long, and the great men, whether in the army or travelling in peace, being always clothed, it never fails to incommode them, whatever ſpecies of raiment they wear. If their cloak is fine muſlin, the leaſt motion againſt it puts it all in rags; but if it is a thick, ſoft cloth, as thoſe are with which men of rank generally travel, it buries its thorns, great and ſmall, ſo deep in it, that the wearer muſt either diſmount and appear naked, which to principal people is a great diſgrace, or elſe much time will be ſpent before he can diſengage himſelf from its thorns. In the time when one is thus employed, it rarely fails to lay hold of you by the hair, and that again brings on another operation, full as laborious, but much more painful, than the other. A proclamation is therefore iſſued, every year immediately before the king commences any march, in theſe words: "Cut down the kantuffa in the four quarters of the world; for I do not know where I am going." The wild animals, both

birds

Kaffon.

birds and beafts, efpecially the Guinea fowl, know how well it is qualified to protect them. In this fhelter, the hunter in vain could endeavour to moleft them, were it not for a hard-haired dog, or terrier of the fmalleft fize, who being defended from the thorns by the roughnefs of his coat, goes into the cover, and brings them and the partridges alive one by one to his mafter.

KASSON, a populous kingdom in North Africa, of which the capital *Kooniakary* is placed by Major Rennel in 14° 33′ N. Lat. and 8° 43′ W. Lon. The king who reigned when Mr Park was in the country was extremely kind to our traveller, though his fon plundered him unmercifully, like other rapacious chiefs of that favage country. From the top of a high hill, at fome diftance from the capital, "I had (fays Mr Park) a moft enchanting profpect of the country. The number of towns and villages, and the extenfive cultivation around them, furpaffed every thing I had yet feen in Africa. A grofs calculation may be formed of the number of inhabitants in this delightful plain, by confidering that the king of Kaffon can raife four thoufand fighting men by the found of his war drum."

At Teefee, a large unwalled town, where our author refided for fome days, he had an opportunity of obferving the cuftoms of the inhabitants, who confifted partly of Pagans and partly of Bufhreens, *i. e.* of negroes converted to Mahomedanifm. Though thefe people poffefs both cattle and corn in abundance, rats, moles, fquirrels, fnakes, locufts, &c. are eaten without fcruple by the higheft and loweft. Another cuftom ftill more extraordinary, is, that no woman is allowed *to eat an egg*. This prohibition, whether arifing from ancient fuperftition, or from the craftinefs of fome old Bufhreen who loved eggs himfelf, is rigidly adhered to; and nothing will more affront a woman of Teefee than to offer her an egg. The cuftom is the more fingular, as the men eat eggs without fcruple in the prefence of their wives, and Mr Park never obferved the fame prohibition in any other of the Mandingo countries.

Our author was prefent at a palaver held by the governor of Teefee on a very extraordinary occafion; of which we fhall give his account at full length, becaufe it fhows how free men are reduced to flavery in North Africa. The cafe was this: "A young man, a Kafir of confiderable affluence, who had recently married a young and handfome wife, applied to a very devout Bufhreen, or Muffulman prieft, of his acquaintance, to procure him faphies for his protection during the approaching war. The Bufhreen complied with the requeft; and in order, as he pretended, to render the faphies more efficacious, enjoined the young man to avoid any nuptial intercourfe with his wife for the fpace of fix weeks. Severe as the injunction was, the Kafir ftrictly obeyed; and without telling his wife the real caufe, abfented himfelf from her company. In the mean time it began to be whifpered at Teefee, that the Bufhreen, who always performed his evening devotion's at the door of the Kafir's hut, was more intimate with the young wife than he ought to be. At firft, the good hufband was unwilling to fufpect the honour of his fanctified friend, and one whole month elapfed before any jealoufy rofe in his mind; but hearing the charge repeated, he at laft interrogated his wife on the fubject, who frankly confeffed that the Bufhreen had feduced her. Hereupon the Kafir put her into confinement, and called a palaver upon the Bufhreen's conduct. The fact was clearly proved againft him; and he was fentenced to be fold into flavery, or to find two flaves for his redemption, according to the pleafure of the complainant. The injured hufband, however, was unwilling to proceed againft his friend to fuch extremity, and defired rather to have him publicly flogged before the governor's gate. This was agreed to, and the fentence was immediately executed. The culprit was tied by the hands to a ftrong ftake; and a long black rod being brought forth, the executioner, after flourifhing it round his head for fome time, applied it with fuch force and dexterity to the Bufhreen's back, as to make him roar until the woods refounded with his fcreams. The furrounding multitude, by their houting and laughing, manifefted how much they enjoyed the punifhment of this old gallant; and it is worthy of remark, that the number of ftripes was precifely the fame as are enjoined by the Mofaic law, *forty*, *fave one*."

Kaffon.

The method of converting the negro nations to the religion of the Arabian Impoftor is a very fingular one; and Mr Park faw the whole people of Teefee converted in an inftant. During his refidence in that town an embaffy of ten people belonging to Almami Abdulkader, king of Foota Torra, a country to the weft of Bondou, arrived at Teefee; and defiring Tiggity Sego the governor to call an affembly of the inhabitants, announced publicly their king's determination, to this effect: "That unlefs all the people of Kaffon would embrace the Mahomedan religion, and evince their converfion by faying eleven public prayers, he (the king of Foota Torra) could not poffibly ftand neuter in the prefent conteft, but would certainly join his arms to thofe of Kajaaga." A meffage of this nature, from fo powerful a prince, could not fail to create alarm; and the inhabitants of Teefee, after a long confultation, agreed to conform to his good pleafure, humiliating as it was to them. Accordingly, one and all publicly offered up eleven prayers, which were confidered a fufficient teftimony of their having renounced Paganifm, and embraced the doctrines of the Prophet.

Our author relates a ftory, which we cannot refufe ourfelves the pleafure of inferting, becaufe it exhibits a very pleafing picture of the affection and gratitude of the Pagan negroes. In his train was a blackfmith, who had lived fome years on the Gambia, and who now returned to his own country *Kaffon*. "Soon after we came in fight of Jumbo, his native town (fays Mr Park), his brother, who had by fome means been apprifed of his coming, came out to meet him, accompanied by a finging man: he brought a horfe for the blackfmith, that he might enter his native town in a dignified manner; and he defired each of us to put a good charge of powder into our guns. The finging man now led the way, followed by the two brothers; and we were prefently joined by a number of people from the town, all of whom demonftrated great joy at feeing their old acquaintance the blackfmith, by the moft extravagant jumping and finging. On entering the town, the finging man began an extempore fong in praife of the blackfmith, extolling his courage in having overcome fo many difficulties; and concluding with a ftrict injunction to his friends to drefs him plenty of victuals.

"When we arrived at the blackfmith's place of refidence, we difmounted and fired our mufkets. The meeting

meeting between him and his friends was very tender; for thefe rude children of nature, free from reftraint, difplay their emotions in the ftrongeft and moft impreffive manner. Amidft thefe tranfports the blackfmith's aged mother was led forth, leaning upon a ftaff. Every one made way for her; and fhe ftretched out her hand to bid her fon welcome. Being totally blind, fhe ftroked his hands, arms, and face, with great care, and feemed highly delighted that her latter days were bleffed by his return, and that her ears once more heard the mufic of his voice. From this interview I was fully convinced, that whatever difference there is between the Negro and European in the conformation of the nofe and the colour of the fkin, there is none in the genuine fympathies and characteriftic feelings of our common nature.

"During the tumult of thefe congratulations, I had feated myfelf apart, by the fide of one of the huts, being unwilling to interrupt the flow of filial and parental tendernefs; and the attention of the company was fo entirely taken up with the blackfmith, that I believe none of his friends had obferved me. When all the people prefent had feated themfelves, the blackfmith was defired by his father to give them fome account of his adventures; and filence being commanded, he began; and after repeatedly thanking God for the fuccefs that had attended him, related every material occurrence that had happened to him from his leaving Kaffon to his arrival at the Gambia; his employment and fuccefs in thofe parts; and the dangers he had efcaped in returning to his native country. In the latter part of his narration he had frequently occafion to mention me; and after many ftrong expreffions concerning my kindnefs to him, he pointed to the place where I fat, and exclaimed, *afille ibi firing*, "fee him fitting there." In a moment all eyes were turned upon me; I appeared like a being dropped from the clouds; every one was furprifed that they had not obferved me before; and a few women and children expreffed great uneafinefs at being fo near a man of fuch an uncommon appearance. By degrees, however, their apprehenfions fubfided; and when the blackfmith affured them that I was perfectly inoffenfive, and would hurt nobody, fome of them ventured fo far as to examine the texture of my clothes; but many of them were ftill very fufpicious; and when by accident I happened to move myfelf, or look at the young children, their mothers would fcamper off with them with the greateft precipitation. In a few hours, however, they all became reconciled to me." With thefe worthy people our author fpent the greater part of two days in feafting and merriment; the blackfmith accompanied him to the capital; and declared, that he would not leave him while he refided there.

KEATE (George, Efq; F. R. S.), defcended of an ancient and honourable family, was born about the year 1729 or 1730, and received his education at Kingfton fchool, under the Rev. Mr Woodefon. From thence he went to Geneva, where he refided fome years; and during his ftay there, became acquainted with Voltaire, with whom he continued to correfpond many years after he returned to England. After finifhing the tour of Europe, he fettled as a ftudent in the Inner Temple, was called to the bar, and fometimes attended Weftminfter Hall; though he did not meet with encouragement enough to induce his perfeverance in his profeffion, nor indeed does it feem probable that he had fufficient application for it. His firft literary performance was "Ancient and Modern Rome," a poem, written at Rome in the year 1755, printed in the year 1760, and received with confiderable applaufe. The next year he publifhed "A Short Account of the Ancient Hiftory, Prefent Government, and Laws, of the Republic of Geneva, 8vo." This work was compiled during the author's refidence at Geneva; is a very ufeful one; and is dedicated to Monfieur de Voltaire; to whom he fays, "When I reflect, that it was in this Republic, whofe government I have attempted to defcribe, that I was firft introduced to your acquaintance; when memory renews the hours of focial mirth and refined entertainment which your hofpitality and converfation afforded me—I cannot but rejoice in this occafion of expreffing my gratitude; proud that, as your friendfhip diftinguifhed the author of thefe pages in a foreign country, your name may at home adorn his labour." It was at one time the intention of Voltaire to tranflate this account into French, though he afterwards relinquifhed the defign.

The next year, 1762, he produced an "Epiftle from Lady Jane Gray to Lord Guildford Dudley:" and in 1763, "The Alps," a poem; the fubject of which comprehends all that chain of mountains known under the general name of the Alps, extending from Italy to Germany, and from France to Tyrol, by whatever denomination they are particularly diftinguifhed. Of all the poetical works of Mr Keate, this is intitled to the higheft praife for truth of defcription, elegance of verfification, and vigour of fancy.

Continuing to employ the prefs, in 1764 he publifhed "Netley Abbey," which he afterwards, in 1769, enlarged and reprinted: and, in 1765, produced "The Temple Student, an Epiftle to a Friend;" humouroufly rallying his own want of application to the ftudy of the law, his preference of the belles lettres, and his confequent want of fuccefs in his profeffion. The death of Mrs Cibber in 1766, of whofe merits as an actrefs he entertained the higheft opinion, gave occafion for a poem to her memory, which celebrates her excellent performances on the ftage, and laments the lofs the theatre would fuftain by her death.

In February 1769, he married Mifs Hudfon; and about the fame time publifhed "Ferney; an epiftle to M. de Voltaire." In this poem, after praifing with energy the various beauties of his friend's poetical works, he introduces the following panegyric on Shakefpeare:

Yes! jealous wits may ftill for empire ftrive,
Still keep the flames of critic rage alive:
Our Shakefpeare yet fhall all his rights maintain,
And crown the triumphs of Eliza's reign.
Above controul, above each claffic rule,
His tut'refs Nature, and the world his fchool,
On foaring pinions borne, to him was given
Th' ærial range of Fancy's brighteft heav'n;
To bid wrapt thought o'er nobleft heights afpire,
And wake each paffion with a mufe of fire.
Revere his genius. To the dead be juft,
And fpare the laurels that o'erfhade the duft.
Low fleeps the bard, *in cold obftruction laid*,
Nor afks the chaplet from a rival's head.
O'er the drear vault, Ambition's utmoft bound,
Unheard fhall Fame her airy trumpet found!

Keate.

Unheard alike; nor grief nor tranfport raife
The blaft of cenfure or the note of praife!
As Raphael's own creation grac'd his hearfe,
And fham'd the pomp of oftentatious verfe,
Shall Shakefpeare's honours by himfelf he paid,
And Nature perifh ere his pictures fade.

This eulogium on Shakefpeare, in an epiftle to Voltaire, who had laboured fo long and fo ftrenuoufly to detract from the merit of our immortal bard, fhews that Mr Keate had not given up his judgment to the fage of Ferney. How the old and envious fophifter would relifh his friend's conduct, may be eafily conceived. His feelings were certainly very different from thofe of the mayor and burgeffes of Stratford, when, in confequence of this panegyric on their townfman, they complimented Mr Keate with a ftandifh, mounted with filver, made out of the famous Mulberry tree planted by Shakefpeare.

In 1775, he publifhed "The Monument in Arcadia," a dramatic poem, built on the picture of Pouffin, mentioned by Abbé du Bos in his "Critical Reflections on Poetry and Painting."

In 1779, Mr Keate produced one of his moft fuccefsful works, entitled "Sketches from Nature; taken and coloured in a Journey to Margate;" 2 vols 12mo. This performance, allowing it to be, as it really is, an imitation of Sterne's "Sentimental Journey;" yet contains fo many pleafing delineations of life, fo many ftrokes of humour, and fo much elegance of compofition, that few will hefitate to give it the preference to any other of Sterne's imitators.

In 1781, he collected his poetical works in two vols, 12mo, and added feveral new pieces not before printed. The principal of thefe was "The Helvetiad," a fragment, written at Geneva in the year 1756. In the preface to this performance he gives the following account of it: "During a long ftay I many years fince made at Geneva, I vifited moft of the principal places in Switzerland. The many fublime fcenes with which nature hath enriched this romantic country; the tranquillity and content with which every individual enjoys his property; and, above all, that independence of mind which is ever the refult of liberty—animated me with fuch veneration for the firft authors of that freedom, whofe figures are recorded to pofterity either by fculpture or painting in the public parts of the towns thro' thofe little ftates, that my enthufiafm betrayed me into a defign of writing a poem on this fingular revolution; the argument of which I had divided into *ten cantos*, beginning the work with the oppreffions of the Houfe of Auftria, and clofing it with the battle of Mongarten; by which thofe injured people finally renounced its ufurpation, and formed among themfelves thofe various confederacies that ended in the great union and alliance of the prefent *thirteen cantons*. When I had fettled the whole plan of this work, I occafionally, as I found a difpofition in myfelf, took up any part of the poem which at the moment moft invited my thoughts: and enjoying at this time fuch an intercourfe with M. de Voltaire as afforded me a conftant accefs to him, I acquainted him with my intention, fhewing him the argument I had drawn out for the conduct of the whole defign. He kept it a few days; and, in returning it, told me, that he thought the great object of the piece, the epifodes connected with the hiftory, together with the fcenery of the country, prefented fubject matter whereon to found a fine poem; "but the time (added he) which fuch an undertaking will require, I would rather counfel you to employ on fubjects that might more engage the public attention; for fhould you devote yourfelf to the completion of your prefent defign, the Swifs would be much obliged to you, without being able to read you, and the reft of the world care little about the matter." Feeling the force and juftnefs of the remark, Mr Keate laid afide his plan, and probably never refumed it. In the fame year, 1781, he publifhed "An Epiftle to Angelica Kauffman."

A few years after, he became engaged in a long and vexatious law-fuit, in confequence of the neglect (to fay the leaft of it) of an architect who profeffed himfelf to be his friend; the particulars of which it is of no importance to detail. At the conclufion of the bufinefs, he fhewed that his good humour had not forfaken him: And in 1787 he gave to the public the principal circumftances of his cafe in a performance, entitled "The Diftreffed Poet, a ferio comic Poem, in three Cantos," 4to, with fome pleafantry, and without any acrimony.

His laft work did infinite honour to his head and his heart, as well as to the liberality of the bookfeller for whom on the title-page it was faid to be publifhed. In the year 1782, the Antelope packet was fhipwrecked on the Pelew iflands, where the commander, Captain Wilfon, and his crew lived fome time before they could get off. On his return to England, the Captain was, for fome reafon or other, refufed the command of another fhip; and, as we have been informed, he was reduced to a ftate much the reverfe of affluence. Thefe circumftances being communicated to Mr Keate, who was ftruck with admiration of the manners of the inhabitants of the Pelew iflands (fee Pelew Islands, *Encycl.*), he offered to draw up, for the benefit of Captain Wilfon, a narrative of the occurrences which took place during that officer's refidence among fo fingular a people. This he executed in "An Account of the Pelew Iflands, fituated in the Weftern Part of the Pacific Ocean: compofed from the Journals and Communications of Captain Henry Wilfon and fome of his Officers, who in Auguft 1783 were there fhipwrecked, in the Antelope, a Packet belonging to the Honourable the Eaft India Company," 4to; a work written with great elegance, compiled with much care, and which, if embellifhed (as it has been infinuated) with facts better calculated to have found a place in a novel than a genuine narrative, muft be afcribed to the mifinformation of thofe who were actors in the fcene, and muft firft have deceived before they obtained credit. We mention this report as it has come to us, without any attempt either to eftablifh or refute it. We fhall only add, that if the charge is well founded, Mr Keate (who undertook the tafk on the moft difinterefted principle, and derived no advantage whatever from the work) was too fturdy a moralift to have had any hand in the impofition.—The manufcript was offered to Mr Dodfley for 300 guineas; but he hefitated to give for it fo large a price, when another bookfeller undertook to publifh the work for the benefit of Mr Wilfon; and, we have reafon to believe, paid to that gentleman, within the compafs of a year, triple the fum for which the manufcript had been offered to Dodfley. Such conduct reflects honour on the London trade.

Befides

Besides the pieces already mentioned, Mr Keate was the author of many Prologues and Epilogues, spoken at Mr Newcomb's school at Hackney. He adapted his friend Voltaire's "Semiramis" to the stage; but this was superseded in 1777 at Drury Lane, by a worthless translation of as worthless an author, one Captain Ayscough; but neither this nor the author are deserving of any further notice.

We shall conclude by observing, that Mr Keate's life passed without any vicissitudes of fortune; he inherited an ample estate, which he did not attempt to increase otherwise than by those attentions which prudence dictated in the management of it. He was hospitable and beneficent, and possessed the good-will of mankind in a very eminent degree. For the last year or two, his health visibly declined; but on the day he died, it appeared to be somewhat mended. His death was sudden, on the 27th of June 1797. He left one daughter, married in 1796 to John Henderson, Esq; of the Adelphi. At the time of his death, Mr Keate was a Bencher of the Temple, and a very old member of the Royal and Antiquary Societies, of both of which he had been frequently elected one of the council.

KENNICOTT (Dr Benjamin) was a man of such eminence in the learned world, that every thing relating to him must be generally interesting. In the biographical sketch of him published in the *Encyclopædia*, we have acknowledged ourselves unacquainted with the rank and character of his parents; but this information has been since supplied by a very candid and well-informed writer in the Monthly Magazine; and as it is accompanied with circumstances peculiarly honourable to the Doctor, and ought therefore to be preserved, we shall insert it in this place.

"The parents of Dr Kennicott (says this writer) were honest characters: His father was the parish-clerk of Totness, and once master of a charity school in that town. At an early age young Kennicott succeeded to the same employ in the school, being recommended to it by his remarkable sobriety and premature knowledge. It was in that situation he wrote the verses to the honourable Mrs Courtney, which recommended him to her notice, and that of many neighbouring gentlemen. They, with laudable generosity, opened a subscription to send him to Oxford.

"He soon there distinguished himself, as is well known. As a testimony of the truth of the above statement, the following is a copy of an inscription written by Dr Kennicott, and engraved on the tomb of his father and mother. The writer of this article has transcribed it from the original in the church-yard of Totness. The tomb is more elegant than persons in their situation are accustomed to have erected, and was thought, perhaps, by the envious to be somewhat ostentatious. A personal knowledge of the Doctor induces the writer of this article to think, that it was rather the tribute of a good and grateful mind, and of the pious reverence and love which he entertained for the authors of his being.

As Virtue should be of good report,
sacred
be this humble Monument
to the Memory of
BENJAMIN KENNICOTT, Parish Clerk of Totness,
and ELIZABETH his Wife:
The latter
an Example of every Christian Duty;
The former,
animated with the warmest Zeal,
regulated by the best good sense,
and both constantly exerted
for the Salvation of himself and others.
Reader!
Soon shalt thou die also;
and as a Candidate for Immortality
strike thy breast and say,
Let me live the life of the Righteous,
that my last end may be like his.
Trifling are the dates of Time
where the subject is Eternity.
Erected
by their Son, B. Kennicott, D. D.
Canon of Christ-Church, Oxford.

"It is said, that when Dr Kennicott had taken orders, he came to officiate in his clerical capacity in his native town. When his father as clerk proceeded to place the surplice on his shoulders, a struggle ensued between the modesty of the son and the honest pride of the parent, who insisted on paying that respect to his son which he had been accustomed to shew to other clergymen: to this filial obedience was obliged to submit. A circumstance is added, that his mother had often declared she should never be able to support the joy of hearing her son preach; and that on her attendance at the church for the first time, she was so overcome as to be taken out in a state of temporary insensibility."

KERMES (see *Coccus Ilicis*, Encycl.) has been proved by Professor Beckmann to have been used as a dye from very remote antiquity. "All the ancient Greek and Latin writers, he says, agree, that kermes, called by the latter *coccum*, perhaps also *coccus*, and often *granum*, were found upon a low shrubby tree, with prickly leaves, which produced acorns, and belonged to the genus of the oak; and there is no reason to doubt that they mean *coccum ilicis*, and that low ever-green oak, with the prickly leaves of the holly (*aquifolium*), which is called at present in botany *quercus ilex*. This assertion appears more entitled to credit, as the ancients assign for the native country of this tree places where it is still indigenous, and produces kermes.

The use of kermes in dyeing seems to have been continued through every century. In the middle ages, as they are called, we meet with kermes under the name of *vermiculus* or *vermiculum*; and on that account cloth dyed with them was called *vermiculata*. Hence the French word *vermeil*, and its derivative *vermilion*, as is well known, had their extraction; the latter of which originally signified the red dye of kermes, but it is now used for any red paint, and also for fine pounded cinnabar.

KHAS, in Bengal, lands taken into the hands of government, opposed to the management of Zemindars or farmers. See ZEMINDAR in this *Supplement*.

KHALSA, in Bengal, sometimes with the addition of *Shereefah*, the department of land and revenues; the exchequer.

KHERAJE, in Bengal, signifies strictly the tribute paid by a conquered country: it is also used for revenue in general.

KHIDMUT,

KHIDMUT, office, attendance, employment, service.

KHIDMUTGAR, a waiting man.

KHISMUT, portion or division.

KHOMAR, or Comar, a Zemindar's demesne land.

KING-Post, or King-*Piece*, is a piece of timber set upwright in the middle, between two principal rafters, and having struts or braces going from it to the middle of each rafter. See Roof, *Encycl.*; and Carpentry, *Suppl.*

KIPPIS (Andrew, D. D. F. R and A. S.), was born at Nottingham, March 28 (O. S) 1725. His father, a respectable tradesman of that town, was descended from the Rev. Benjamin King of Oakham, Rutlandshire, an ejected minister; and his mother, Ann Ryther, was the grand-daughter of the Rev. John Ryther, who was ejected from the church of Fernby, in the county of York. In the year 1730, he lost his father, and went to reside with his grandfather, Andrew Kippis of Seaford in Lincolnshire. He received his classical education at the grammar school in that town; but what contributed most to his future eminence, was the friendship of the Rev. Mr Merrival, who was equalled by few of his contemporaries in various branches of learning, particularly in his acquaintance with the classics, his knowledge of ancient and modern history, and his refined taste in the belles lettres. Dr Kippis frequently said, that it was impossible for him to express his obligations to this friend of his youth. In 1741 he removed to Northampton, and commenced his academical studies under Dr Doddridge. After a residence of five years at the academy, he was invited by several congregations to become their minister. Though he was pressed to settle at Dorchester, and had been chosen their minister, he gave the preference to an invitation from Boston in Lincolnshire, where he went to reside in September 1746. Here he continued four years; and in November 1750, accepted the pastoral charge of a congregation at Dorking in Surry. The congregation meeting in Princes-Street, Westminster, having been without a minister about two years, he was chosen, in June 1753, to succeed the Rev. Dr Obadiah Hughes. On the 21st of September following, he married, at Boston, Miss Elizabeth Bott, one of the daughters of Mr Isaac Bott, a merchant of that place; and in the month of October fixed his residence in Westminster. In June 1767, he received the degree of D. D. from the university of Edinburgh, on the unsolicited recommendation of the late learned Professor Robertson. He was elected a member of the Society of Antiquaries on the 19th of March 1778; and on the 17th of June 1779, he was chosen a fellow of the Royal Society. In both Societies he had the honour of being in the council two years.

Dr Kippis was eminently distinguished for the virtues and accomplishments which form the chief ornaments of private life. With a suavity of manners and urbanity of behaviour peculiarly attractive, he united that knowledge of men and books which rendered his conversation uncommonly entertaining and instructive to the circle of his acquaintance and friends. As a minister, he was not less eminent for his profound acquaintance with every branch of theology than for the happy manner in which he applied it to the improvement of those who attended his ministry. His sermons were remarkable for perspicuity, elegance, and energy; and his elocution was unaffected and very impressive, particularly at the close of his discourses. But the superior powers and vigour of mind which he derived from nature, and which he had cultivated with unremitting diligence and peculiar success, were not to be confined to the narrow limits of private life and the duties of the pastoral charge, however important; they were designed for more extensive and important services to his country and to mankind. The interests of literature, science, and religion, have received from the exertion of his talents as a writer the most essential advantages. His first efforts in literature were made in the Gentleman's Magazine, a periodical publication called the Library, and the Monthly Review; to each of which he contributed many important articles, especially in the historical and philological departments of the last. He was the author of three important tracts, viz. "A Vindication of the Protestant Dissenting Ministers, &c." "Observations on the late Contests in the Royal Society;" and "Considerations on the Treaty with America, &c." His improved edition of Dr Doddridge's Lectures is a work of great value; and "The History of Knowledge, Learning, and Taste, in Great Britain," prefixed to the New Annual Register, merits, and has received, the approbation of the public. He published at different times several single sermons; among which, that on the death of his friend the Rev. Mr Laugher, is intitled to very high praise. The greater part of these he republished, with other practical discourses, in the year 1794: but the work which, next to the studies immediately connected with his office as a Christian minister, engaged his principal attention, and by which he has long been distinguished, is, the improved edition of the "*Biographia Britannica.*" In this great national publication, the comprehensiveness and powers of his mind, the correctness of his judgment, the vast extent of his information, his indefatigable researches and unremitting assiduity, his peculiar talent of appreciating the merits, and analyzing the labours of the most eminent writers, and his unshaken integrity, unbiassed fidelity, and impartial decision on the characters of the philosopher, statesman, poet, scholar, and divine, are strongly displayed, and universally acknowledged. His style, formed on the models of Sir William Temple and the classical Addison, is remarkable for its perspicuity, elegance, and purity; and gives a peculiar lustre to the rich stores of knowledge treasured in the volumes now published. This work has given him a high rank among the literati of his country, and will carry down his name with distinguished reputation to posterity. He died on the 8th October 1795.

KLIP-Springer. See Kainsi, *Suppl.*

KOL Quall, the Abyssinian name of a tree, which some botanists have supposed to be the Euphorbia *Officinarum* of Linnæus. Mr Bruce, who gives the only description of the Kol-quall that we have seen, is of a different opinion: for which he assigns two reasons; the first is, that the flower, which he says is rosaceous, is composed of several petals, and is not companiform; and the second, that it produces no sort of gum, either spontaneously or upon incision. We must acknowledge, that we entertain some doubts whether our author was at due pains to ascertain this fact; and these doubts are suggested by his own history of the tree. His

His defcription is not very perfpicuous, and therefore, left we fhould mifreprefent his meaning, we fhall give it in his own words:

"The firft thing that prefented itfelf was the firft fhoot of this extraordinary tree. It was a fingle ftalk, about fix inches meafured acrofs, in eight divifions, regularly and beautifully fcolloped and rounded at the top, joined in the centre at three feet and a half high. Upon the outfide of thefe fcollops were a fort of eyes or fmall knots, out of every one of which came five horns, four on the fides and one in the centre, fcarce half an inch long, fragil, and of no refiftance, but exceedingly fharp and pointed. Its next procefs is to put out a branch from the firft or fecond fcollop near the top, others fucceed from all directions; and this ftalk, which is foft and fucculent, of the confiftence of the aloe, turns by degrees hard and ligneous, and after a few years, by multiplying its branches, affumes the form of a tree, the lower part of which is wood, the upper part, which is fucculent, has no leaves; thefe are fupplied by the fluted, fcolloped, ferrated, thorny fides of its branches. Upon the upper extremity of thefe branches grow its flowers, which are of a golden colour, rofaceous, and formed of five round or almoft oval petala; this is fucceeded by a triangular fruit, firft of a light green with a flight caft of red, then turning to a deep crimfon, with ftreaks of white both at top and bottom. In the infide it is divided into three cells, with a feed in each of them; the cells are of a greenifh white, the feed round, and with no degree of humidity or moifture about it; yet the green leaves contain a quantity of bluifh watery milk almoft incredible.

"Upon cutting two of the fineft branches of a tree in its full vigour, a quantity of this iffued out, which I cannot compute to be lefs than four Englifh gallons; and this was fo exceedingly cauftic, that though I wafhed the fabre that cut it immediately, the ftain has not yet left it.

"When the tree grows old, the branches wither, and, in place of milk, the infide appears to be full of powder, which is fo pungent, that the fmall duft which I drew upon ftriking a withered branch, feemed to threaten to make me fneeze to death, and the touching of the milk with my fingers excoriated them as if fcalded with boiling water; yet I everywhere obferved the wood-pecker piercing the rotten branches with its beak, and eating the infects, without any impreffion upon its olfactory nerves."

If what is milk in a young tree be a dry powder in one that is old, is it not probable that the milk might by evaporation be reduced to the confiftence of gum, and that the kol-quall may be at moft but a variety of the *euphorbia officinarum?* From our author's obfervation, the kol-quall appeared to thrive beft on poor, fandy, ftony earth, at no great diftance from the fea. The Abyffinians employ the milky juice in tanning to take off the hair from the fkins, and they make no other ufe whatever of the tree.

KOONA, a fpecies of ECHITES (for which fee *Encycl.*), very common in the woods of North Africa. It is a fhrub, of which the leaves, when boiled with a fmall quantity of water, yield a thick black juice, into which the negroes dip a cotton thread. This thread they faften round the iron of their arrows, in fuch a manner that it is almoft impoffible to extract the arrow when it has funk beyond the barbs, without leaving the iron and the poifoned thread in the wound. The poifon of the koona is faid to be very deadly.—*Park's Travels.*

KORAQUAS, a tribe of Hottentots inhabiting a diftrict of South Africa, which M. Vaillant places on the confines of the Nimiqua country (See NIMIQUAS, *Suppl.*). When our author vifited them, the whole tribe was affembled for the election of a chief: and not agreeing among themfelves, fome blood had been fhed, and much more would have been fhed, had they not unanimoufly made choice of him. When he firft joined them, the whole horde paid attention to nothing but their quarrel. To fee their warmth, one might have fuppofed that their election was a matter of importance to the whole world, and that the fate of mankind was about to depend on their chief. All fpoke at the fame time; each endeavoured to drown his neighbour's voice by his own; their eyes fparkled with fury; and amidft this confufion, while they threatened each other in turns, the noife they made became truly dreadful.

Unarmed, and without any precaution, though furrounded by this enraged multitude, our author walked calmly along in the midft of them; and when he reached the kraal, he ordered his tent to be immediately formed, as if he had been furrounded by friends and relations. This appearance, raifed fuddenly, and as if by magic, before the eyes of the horde, with his fufees, horfes, and tent, objects which were all new to them, filled them with admiration. Men, women, and children, motionlefs, and with their mouths wide open, all ftood looking at them with profound filence. Anger, hatred, and every violent paffion, feemed by their countenances to be extinguifhed, and to have given place to more tranquil emotions, to ignorant furprife, and ftupid aftonifhment. Infancy is naturally curious; it is ftruck with every thing it fees; and the favage, in this refpect, is only a grown-up child. As thefe favages feemed to wifh that he would permit them to examine more clofely whatever excited their admiration, he readily condefcended to gratify their defire. They approached, furveyed, and handled every thing. But the principal object of general curiofity was his perfon. They feemed as if they would never be fatisfied with looking at his drefs. They pulled off his hat, that they might the better examine his hair and his beard, which were long. They even half unbuttoned his clothes; and furprifed to fee his fkin white, each felt it, as if defirous to afcertain that what they faw was real.

This comedy continued till the evening; and at length, when the moment of feparation arrived, M. Vaillant caufed to be hinted to the whole company, that if, two hours after fun rife next morning, they fhould not be agreed refpecting the choice of a chief, he would immediately leave them. He added, however, that if, on the other hand, they came and prefented to him a chief, elected by general confent, he would then load them all with prefents, and beftow on him a diftinction which would raife him above all his equals, and render the horde one of the moft celebrated in the whole country. "But what was my furprife (fays he) when I learned the fame evening, that on my head the burden of the crown was depofed!" He acquiefced, however; affuring them, that if they would promife to be obe-

dient,

dient, he would give them the only chief worthy of ruling them, and of making them happy.

By his interpreters he had learned, that the choice of the majority leaned towards one Haripa, a man about 40 years of age; tall, well made, exceedingly ſtrong, and conſequently formed by nature for ruling the feeble multitude. He therefore named Haripa chief; and the people appearing to approve of his choice, he commanded ſilence, and cauſing the new monarch to approach, placed on his head, with great ſolemnity, a Dutch grenadier cap, of which the copperplate on the front was ornamented with the arms of Holland. This ſymbol *viz.* a lion rampant, having in one of his fore-paws ſeven arrows, and in the other a naked ſabre, could not fail to pleaſe the ſavages, as it exhibited a repreſentation of the weapons peculiar to them, and of the moſt formidable animal of their country. They teſtified their admiration in the moſt expreſſive manner; and imagined that, ſuperior to kings, the white man during the night had by magic made this crown, merely to adorn their chief, and to afford them pleaſure. Vaillant then affixed to the ſkin, which formed Haripa's dreſs, ſeveral rows of glaſs beads; gave him a girdle made of a ſtring of very large ones; ornamented his arms with tin bracelets, and ſuſpended from his neck a ſmall padlock, ſhaped like a butterfly, the key of which had been loſt. Such padlocks, made in the form of animals of every kind, are very common at the Cape. They come from China; and are brought to Africa by the captains of the Company's ſhips which trade in the Indian ſeas.

During the ceremony of inſtallation, the whole horde, dumb and motionleſs through admiration, ſeemed loſt in ecſtacy. Haripa himſelf, though highly gratified, did not dare to make the leaſt movement, and obſerved a gravity altogether riſible. When the inauguration was finiſhed, and he was completely dreſſed, our author preſented him with a mirror, that he might enjoy the ſatisfaction of ſurveying his own figure. He then ſhewed him to the people, who expreſſed their joy by ſhouts and applauſes without end.

" Ye honeſt hearts (ſays M. Vaillant), who peruſe this account, behold what it coſt me to reſtore peace among a whole tribe, and to prevent them from deſtroying each other!" From this moment concord was reeſtabliſhed; univerſal joy prevailed through the horde; and they inſtantly began their dancings, which continued for three days and three nights without intermiſſion. They killed for this feſtival ſeveral fat ſheep, and even two oxen; an extraordinary and truly aſtoniſhing magnificence among a people who, when they barter one of their daughters for a cow, think they have made an excellent bargain.

Our author, wiſhing to purchaſe ſome oxen for his waggons, bought them at the price of a nail the ox; and thoſe who had the good fortune to make ſuch an exchange were highly ſatisfied with their bargain. Nails and ſmall bits of iron were indeed of real value to them, to point the arrows and aſſageys with which they ſhot the antelopes that abound in their country, and conſtitute much of their food. Like other ſavages, the Koraquas were ready to pilfer, and appropriate to their own uſe whatever they found pleaſing, or ſuited to their purpoſes. They attempted to carry away ſome of our author's effects, even before his face; and to prevent their rapacity, he was obliged either to watch over, or to depoſit them in ſome place of ſafety.

The Koraquas are much taller than the Hottentots of the colonies, though they appeared evidently to be deſcended from the ſame race, having the ſame language and cuſtoms with their neighbours the NIMIQUAS (ſee that article), who are certainly of Hottentot extraction.

As the exceſſive dryneſs of the country renders ſprings very rare, the Koraquas would be unable to inhabit it, had they not found the means of remedying this ſcarcity of water. For this purpoſe they dig in the earth a kind of ciſterns or rather wells, to which they deſcend gradually by ſteps; and theſe people are the only African nation among whom our author ever found the ſame mark of induſtry.

As their wells always contain little water, and as none is to be loſt, they take care to ſecure it even from the birds, by cloſing up the mouth of the hole with ſtones and the branches of trees; ſo that, unleſs one knows the ſpot, it is impoſſible to find it. They go down into it every day, to fetch up as much water as may be neceſſery for the conſumption of their people and cattle. They draw it in a kind of veſſels made of hollowed wood, and pour it into the ſkins of buffaloes or giraffes, placed in a concave form on the ground to hold it; but they diſtribute it with the utmoſt parſimony, and never draw more than they abſolutely have occaſion for.

Notwithſtanding this ſtrict economy, the wells often become dry; and in that caſe the horde is obliged to remove to ſome other place. Among all the weſtern tribes, therefore, there are none who lead ſo wandering a life as the Koraquas: the conſequence of which is, that, as they often change their abode, and acquire new neighbours, they muſt, in ſome meaſure, adopt the cuſtoms of the nations near which they fix their reſidence. Some tribes of them greaſe themſelves like the Hottentots; while others tattoo their face, breaſt, and arms, after the manner of the Caffres. It is, however, to be remarked, that the ſame colour is not employed by all the Koraquas; each has his own, according as caprice may direct him in his choice, and it generally varies every day; which renders, as one may ſay, the inhabitants of the ſome horde ſtrangers to each other, and gives them a motley appearance, as if they were dreſſed for a maſquerade.

KRISHNA or CRISNA, is an eaſtern river of conſiderable magnitude, which is very little known in Europe. We have the following account of it, and its tributary waters, and the countries through which it flows, in Mr Pennant's view of Hinduſtan:

" From Gangapatam, on the northern mouth of the Pennar, the land runs due north as far as Mottapilli, when it forms a ſtrong curve toward the eaſt; the point of which is one ſide of the great river Criſna, in about lat. 15° 43'. Its Delta, which winds round as far as Maſulipatam, is not conſiderable. This river annually overflows a vaſt tract of country, like the Indus on the weſtern ſide of this empire, and like all the other great rivers on this extenſive coaſt. The Criſna riſes from the foot of the weſtern Ghauts, and not more than 45 miles from Severndrug, on the weſtern coaſt. There is another branch to the eaſt, that riſes ſtill more northerly. On that ſide is Sattara, a ſtrong fortreſs, the capital of the Mahratta ſtate in the time of the rajahs of

Krishna. Sivaji's race. It was taken by him in 1673, and found to be the depofitory of immenfe treafure; at that time it belonged to the king of Vijapur: it was afterwards ufed by the Mahrattas as the lodgment of their riches, and alfo as a retreat for the more defencelefs inhabitants of Puna, and other open towns, in time of potent invafions.

" The river continues defcending to the eaft. In latitude 17° is Meritch, a ftrong fortrefs, with a Jaghirdar territory, conquered from its owner by Hyder. In lat. 16° 45′, a fmall river difcharges itfelf into the Crifna from the north. It would not be worth mentioning, but that Pannela, a fortrefs of vaft ftrength, was made by Sumbuji, the profligate fon of Sivaji, his refidence juft before his furprifal in 1689, betrayed by Cablis Khan, the vile inftrument of his pleafures, corrupted by Aurengzebe. His extravagant love of women brought on him ruin. Informed by Cablis that a Hindu of rank and great beauty was on the road to be delivered by her parents to her hufband, according to the cuftom of the Hindus, he inftantly put himfelf at the head of a fmall body of horfe to carry off the prize, and ordered Cablis to follow at a diftance for his protection, in cafe of accidents in that hoftile time. The traitor had given notice to Aurengzebe of this expedition, who, fending a body of cavalry, furprifed Sumbuji juft as he had difperfed the nuptial proceffion.

" Into the north fide of the Crifna, in lat. 16° 20′, falls the great river Bima, after a courfe of 350 miles. It rifes at the head of the weftern Ghauts, parallel to Chaul in the Concan, and not above 50 miles from the fea. It defcends rapidly towards the fouth-eaft. In lat. 17° 40′ it receives a fmall river from the weft, on the fouthern banks of which ftands Vijapur, the capital of the famous kingdom of the fame name, now poffeffed by the Mahrattas, but once governed by its own monarchs, till conquered by Aurengzebe in 1686. It was of great extent, and reached to the weftern fea, where it poffeffed the ports of Dabul, Vingorla, and Carapatan.

" The capital Vijapur is fome leagues in circuit, feated in a fine but naked country, well watered. It makes a fingular appearance from an adjacent eminence, filled with numbers of fmall domes, and one of a majeftic fize. It was once a city of great fplendour, and filled with palaces, mofques, maufoleums, and public and private buildings of great magnificence; many of them are fallen to ruin, and give melancholy proofs of its former fplendour. I fhall not attempt to detail them. The palaces of the kings, and accommodations for their attendants, were within a vaft fort, furrounded with a ditch 100 yards wide; the depth appeared to be great, but is now filled with rubbifh: within the fort is the citadel. Tavernier fays, that the great ditch was filled with crocodiles, by way of garrifon, to prevent all accefs by water. Lieutenant Moor has his doubts about this, imagining that there never was any water in this fofs. That fuch garrifons have exifted I doubt not. I have read in Purchas, that in Pegu the foffes of fortified places were ftocked with thofe tremendous animals, not only to keep out enemies, but to prevent defertion. This practice has certainly been of great antiquity in fome parts of India: Pliny mentions it as ufed in a fair city of the Horatæ, a people I cannot trace.

" The Crifna, above and below its conflux with the Bima, is fordable; and a few miles below its channel is 600 yards wide, made horrid with the number and rudenefs of the varioufly formed rocks, which are never covered but in the rainy feafon. Krifhna, Kuara.

" The Tungbuddra is another vaft branch of the Crifna. It falls into it in lat. 16° 25′, and originates extremely fouth, from a doubtful fountain. Towards its lower part it divides into three or four fmall branches, which rife remote from each other; the moft fouthern is the Curga Nair's country; the moft northern from the head of the Ghauts oppofite to Onor, and fcarcely 20 miles from the fea. What muft give this river great celebrity, is its having had on its banks, in lat. 15° 22′, the fplendid city of Vijanagar. Ferifhta fays, that it was founded in 1344 by Belaldeo king of the Carnatic, which in thofe days included the whole peninfula. It was vifited by Cæfar Frederick a Venetian travellar, in 1565, and found deferted and ruinous, having been facked by four confederated Mahomedan princes two years before, on which its monarch had retired to Penuconda. Frederick fays that its circumference was 24 miles. Mr Rennel has given us a view of its prefent ftate from Lieutenant Emitt, who vifited it in 1792.

" The ruins of Vijanagar are in the little Sircar of Anagundi, which does not extend above 20 miles around this vaft city. It is very fingular that that little Sircar is now poffeffed by a lineal defcendant of Rama Rajah, the laft great monarch of Vijanagar, and its attendant nations Canarine and Malabar, united 700 years before under the rule of Crifna Deva. Tippu wifhed to referve this little tract to himfelf, for the fatisfaction of generoufly reftoring to the defcendant the fmall relique of the great empire of his anceftors. He is denied the title of Rajah; inftead of which he has the diminutive Rail beftowed on him. This is fuitable to his revenues, which do not exceed two lacs of rupees, or 25,000 *per annum*, with the empty regality of a mint at Anagundi." In the remainder of its courfe the Crifna offers nothing remarkable.

KUARA, is a beautiful tree, which grows in the fouth and fouth-weft parts of Abyffinia. With the ebony it is almoft the only wood of the province of Kuara, of which it bears the name; but Mr Bruce affures us, that it is very frequent in all the countries where there is gold. " It is (fays he) what naturalifts call *a Corallodendron*, probably from the colour of its flowers or of its fruit, both equal in colour to coral. Its fruit is a red bean, with a black fpot in the middle of it, which is inclofed in a round capfula or covering, of a woody nature, very tough and hard. This bean feems to have been in the earlieft ages ufed for a weight of gold among the Shangalla, and, where that metal is found, all over Africa; and by repeated experiments, I have found that, from the time of its being gathered, it varies very little in weight, and may perhaps have been the very beft choice that therefore could have been made between the collectors and buyers of gold.

" I have faid this tree is called kuara, which fignifies the fun. The bean is called *carat*, from which is derived the manner of efteeming gold as fo many carats fine. From the gold country in Africa it paffed to India, and there came to be the weight of precious ftones, efpecially diamonds; fo that to this day in India we hear it commonly fpoken of gold or diamonds, that they are of fo many carats fine or weight. I have feen

Kumi.

these beans likewife from the Weft-Indian iflands. They are juft the fame fize, but, as far as I know, are not yet applied to any ufe there."

This is a very different account from the origin of the term Carat from what we have given in the *Encyclopædia*; but the reader will judge for himfelf between the two.

KUMI, the name of an ifland between Japan and China, of which Peroufe writes in the following terms: "On the 5th of May, at one o'clock in the morning, we made an ifland, which bore north north-eaft of us; we paffed the reft of the night, ftanding off and on, under an eafy fail, and at day-break I fhaped my courfe fo as to run along the weft coaft of this ifland, at the diftance of half a league. We founded feveral times without finding bottom. We were foon fatisfied that this ifland was inhabited, for we faw fires in feveral places, and herds of oxen grazing on the fea-fhore. When we had doubled its weft point, which is the moft beautiful and beft inhabited fide, feveral canoes put off from the fhore in order to obferve us. They feemed to be extremely in fear of us; their curiofity caufed them to advance within mufket fhot, and their diftruft made them immediately flee away with fpeed. Our fhouts, geftures, figns of peace, and the fight of fome ftuffs, at length determined two of the canoes to come alongfide of us. I made each of them a prefent of a piece of nankeen and fome medals. It was evident that thefe iflanders had not left the coaft with any intention of trafficking with us, for they had nothing to offer in exchange for our prefents; they only faftened to a rope a bucket of frefh water, making figns to us, that they ftill thought themfelves in our debt, but that they were going afhore to fetch provifion, which they expreffed by putting their hand into their mouth. Before coming alongfide the frigate, they placed their hands upon their breaft, and raifed their arms towards the fky: thefe geftures were repeated by us, and then they refolved to come on board; but it was with a want of confidence, which was ftrongly expreffed in their countenance during the whole time. They neverthelefs invited us to approach the land, giving us to underftand, that we fhould there want for nothing. Thefe iflanders are neither Japanefe nor Chinefe, but, fituate between thefe two empires, they feem to partake of both people. Their covering was a fhirt and a pair of cotton drawers. Their hair, tucked up on the crown of the head, was rolled round a needle, which feemed to us to be gold: each of them had a dagger, the handle of which wes gold alfo. Their canoes were made out of hollowed trees, and they managed them very indifferently. I could have wifhed to land upon this ifland; but as we had brought the fhip to, in order to wait for thefe canoes, and as the current fet to the northward with extreme rapidity, we had drifted a great way to leeward, and our efforts to reach it would perhaps have been in vain: befides, we had not a moment to lofe, and it was of the higheft importance to us to get out of the Japan feas before the month of June; a period of ftorms and hurricanes, which render thefe feas the moft dangerous in the whole world.

"It is clear, that veffels which might be in want would readily provide themfelves with provifion, wood, and water, in this ifland, and perhaps even carry on a little trade; but as it is not more than three or four leagues in circumference, there is no great probability that its population exceeds four or five hundred perfons; and a few gold needles are not of themfelves a proof of wealth." Our author, by obfervation, found the latitude of Kumi to be 24° 33′ north; its longitude 120° 56′ eaft from Paris.

Kuriles.

KURILES, are a clufter of iflands, of which fome account has been given under the word Kuril, in the *Encyclopædia*. In addition to that article, the following particulars are worthy of notice: Of the 21 iflands belonging to Ruffia, which are diftinguifhed from each other, not by names but by numbers, four only are inhabited, viz. thofe which are called the firft, the fecond, the thirteenth, and the fourteenth. The laft two may indeed be counted only as one, becaufe the inhabitants all pafs the winter upon N° 14, and return to N° 13 to pafs the fummer months. The others are entirely uninhabited, the iflanders only landing there occafionally from their canoes for the fake of hunting foxes and otters. Several of thefe laft mentioned iflands are no better than large rocks, and there is not a tree on any one of them. The currents are very violent between the iflands, particularly at the entrance of the channels, feveral of which are blocked up by rocks on a level with the fea. The population of the four inhabited iflands amounts at moft to 1400 fouls. The inhabitants are very hairy, wear long beards, and live entirely upon feals, fifh, and the produce of the chace. When vifited by M. Peroufe, they had juft been exempted for ten years from the tribute ufually paid to Ruffia, becaufe the number of otters on their iflands is very much diminifhed. Thefe poor people are good, hofpitable, and docile, and have all embraced the Chriftian religion. The more fouthern and independant iflanders fometimes pafs in canoes the channels that feparate them from the Ruffian Kuriles, in order to give fome of the commodities of Japan in exchange for peltries.

L.

Labdaffeba.

LABDASSEBA, a tribe of favage Arabs who inhabit the defart of Sahara in Africa. They are the moft powerful of all thofe tribes except the Ouadelims; and they refemble thefe fo much in every thing, that we fhall give an account of the manners of both under the title Ouadelims, and of their country under that of Sahara.

Laboratory.

LABORATORY, is an apparatus fo neceffary to the

Laboratory.

the chemift, that every contrivance to render it more convenient, or to leffen the expence of it, muft contribute greatly to the advancement of fcience. The abilities of *Morveau* alias *Guyton*, and the fuccefs with which he has profecuted the ftudy of chemiftry, are well known; and therefore his different methods of faving time and expence in making chemical experiments muft be worthy of the notice of younger chemifts.

In the fecond volume of the memoirs of the Ancient Academy of Dijon, we have a defcription by him of a box containing a kind of portable laboratory, compofed of a lamp with three wicks, difpofed in the figure of an equilateral triangle, to form an internal current of air, with fupports for the different veffels of digeftion, diftillation, evaporation, &c. He made a folution of filver with common aqua fortis and the metal in an alloyed ftate, which anfwered very well as a re-agent, without having occafion for any other utenfils but this box and apothecary's phials, which are everywhere to be found.

This apparatus, however, was confined in its application, and he foon thought of improving it. He conftructed a lamp, on the principles of Argand, with three concentric circular wicks, each having an interior and exterior current of air. The effect furpaffed his expectations with regard to the intenfity of the heat; but it was difficult to prevent the deftruction of the hard folder round the wicks; and the glafs retorts were frequently melted at the bottom, and disfigured. It was attended with other inconveniences, and the quantity of oil confumed was great.

A fhort time afterwards, it occurred to him to fubftitute, inftead of the glafs chimney of Argand's lamp, a cylinder of copper with an indented part or ledge a few millimetres (fee Revolution, *Encycl.* n° 183.) above the flame, to perform the office of the indented chimney of glafs, and by that means to render it practicable to raife the wick to a certain height without fmoaking. This cylinder has three branches like a chaffing-difh. By this apparatus two or three decilitres of water (about half an Englifh wine pint) may be brought to boil in a copper or glafs veffel in about fix or feven minutes. It has ferved for a number of operations; but it was not till after he had obferved the degree of heat obtained from the lamp in its ordinary ftate, and particularly fince he had fubftituted inftead of the metallic tube a chimney of glafs cut off at the length of three centimetres (rather more than one Englifh inch) above the contraction, that he perceived all the advantages it was capable of affording; and that by means of a moveable fupport for the reception of the different veffels, which may be fixed at pleafure by a thumb-fcrew, this lamp furnace, at the fame time that it gives light, and confequently without any additional expence, may with facility be ufed for almoft every one of the operations of chemiftry; fuch as digeftions, folutions, cryftallizations, concentrations; the rectification of acids; diftillations on the fand-bath, or by the naked fire; incinerations of the moft refractory refidues; analyfes with the pneumatic apparatus, or of minerals by the faline fufion, &c. "I have not (fays he) hitherto met with any exception but for complete vitrifications and cupellations; for even the diftillations to drynefs may be performed with fome precautions, fuch as that of transferring the matter into a fmall retort blown by the enameller's lamp, and placing its bottom on a little fand-bath in a thin metallic difh." The fupport here mentioned is fimply a copper ring eight centimetres (3,15 inch.) in diameter, which is raifed or lowered by fliding on a ftem of the fame metal. Nothing more was required but to adapt it to the fquare iron ftem which paffes through the refervoir of the lamp. The connection is made by a piece of wood, in order that lefs of the heat might be difperfed. As the lamp itfelf is capable of being moved on its ftem, it is eafy to bring it nearer or remove it at pleafure from the veffels, which remain fixed; a circumftance which, independent of the elevation or depreffion of the wick, affords the means of heating the retorts by degrees, of moderating or fuppreffing the fire inftantly, or of maintaining it for feveral hours at a conftant or determinate intenfity, from the almoft infenfible evaporation of cryftallizable folutions to the ebullition of acids; properties never poffeffed by the athanor, of which chemifts have boafted fo much The advantage of thefe will be properly valued by thofe operators who know that the moft experienced and the moft attentive chemifts meet with frequent accidents, by which both their veffels and the products of their operations are loft for want of power in the management of the fire."

For the analyfis of ftones, fuch as the cryftals of tin, the fhortened chimney of glafs is to be ufed; and the procefs is to be begun by placing the mixture in a capfule of platina or filver $2\frac{1}{4}$ inches in diameter. This capfule is to be placed on the fupport, and the heat regulated in fuch a manner, that ebullition fhall take place without throwing any portion of the matter out of the veffel. As foon as its contents are perfectly dry, they are to be transferred into a very thin crucible of platina, of which the weight is about $252\frac{1}{2}$ grains Englifh, and its diameter one inch and three-fourths. This crucible refts on a fmall fupport of iron-wire, which ferves to contract the ring; and the wick being at its greateft elevation, with the ring lowered to the diftance of $9\frac{1}{2}$ inches from the upper rim of the chimney, Guyton produced, in lefs than twenty minutes, the faline fufion to a fuch a degree, that from the commencement of the operation the decompofition proceeded as far as to 0.70 of the mineral. The fame apparatus, that is to fay, with the fhortened chimney, ferves for oxidations, incinerations, torrefactions, and diftillations to drynefs.

In fuch operations as require a lefs heat, he leaves the lamp with its large chimney abfolutely in the fame ftate as when it is ufed for illumination; and by raifing and lowering either the ring which fupports the veffel, or the body of the lamp if the veffels be fixed in communication with others, he graduates the heat at pleafure. Vinegar diftils without interruption at $2\frac{1}{7}$ inches Englifh from the upper termination of the chimney, that is to fay, $7\frac{1}{7}$ inches Englifh from the flame. Water is made to boil in eight minutes, at the fame height, in a glafs veffel containing one wine pint Englifh, and is uniformly maintained at the diftance of $8\frac{1}{7}$ inches from the flame.

"I muft not in this place (fays our author) omit to mention a flight obfervation which this procefs has afforded, becaufe it may lead to ufeful applications, and tends to point out one great advantage of this method of operating; namely, that an infinity of circumftances may be perceived, which might not even be fufpected when the whole procefs is carried on within a furnace. I have remarked, as did likewife feveral of my colleagues

Laboratory.

who were then prefent, that a column of bubbles conftantly rofe from a fixed point of the retort on one fide of the bottom. We were of opinion, that fome particle of matter was in that place incorporated with the glafs, which had a different capacity for heat from that of the reft of the glafs. In order to verify this conjecture, I endeavoured the following day to diftil the fame quantity of the fame water in the fame retort, after having introduced a button of cupelled filver, weighing nine decigrammes ($29\frac{1}{2}$ grains). At the commencement of the operation there was a fmall ftream of bubbles from the fame point as before; but a fhort time afterwards, and during the whole remaining time of operating, the largeft and moft inceffant ftream of bubbles rofe from the circumference of the button, which was often difplaced by the motion; and in proportion to the time the product of the diftillation was fenfibly greater. Whence we may conclude, that metallic wires or rods, diftributed through a mafs of water, required to be kept in a ftate of ebullition, and placed a little below its furface, would produce, without any greater expence of fuel, nearly the fame effect as thofe cylinders filled with ignited matter which are made to pafs through the boilers."

We have related this fact in Guyton's own words, or at leaft in a faithful tranflation of them; and we are far from calling it in queftion, for it is a fact which has been often obferved: but we think his inference from it too haftily drawn. It is not conceivable that heat can be more rapidly conveyed through a mafs of liquid by the conducting power of metal, than by a free circulation; but we agree with what feems to be Mr Nicholfon's opinion *, that the thin ftratum of water beneath the button becomes more fuddenly and violently elaftic than elfewhere, and therefore rifes regularly to the furface. The whole of this phenomenon the reader will find explained in our article STEAM, *Encycl.* n° 10. But this is a digreffion.

* *Journal*, Auguft 1798, note, page 212.

We return, therefore, to Guyton's laboratory, of which the reader will form a diftinct notion from plate XXXIII. where fig. 1. reprefents the whole apparatus ready mounted for diftillation, with the tube of fafety and a pneumatic receiver. A is the body or refervoir of the ufual lamp of Argand, with its fhade and glafs chimney. The lamp may be raifed or lowered at pleafure by means of the thumb fcrew B, and the wick rifes and falls by the motion of the fmall toothed wheel placed over the wafte cup. This conftruction is moft convenient, becaufe it affords the facility of altering the pofition of the flame with regard to the veffels, which remain fixed; and the troublefome management of bended wires above the flame for the fupport of the veffels is avoided, at the fame time that the flame itfelf can be brought nearer to the matter on which it is intended to act. D, a fupport confifting of a round ftem of brafs, formed of two pieces which fcrew together at about two thirds of its height. Upon this the circular ring E, the arm F, and the nut G flide, and are fixable each by its refpective thumb-fcrew. The arm alfo carries a moveable piece H, which ferves to fufpend the veffels in a convenient fituation, or to fecure their pofition. The whole fupport is attached to the fquare iron ftem of the lamp by a piece of hard wood I, which may be fixed at any required fituation by its fcrew. K reprefents a ftand for the receivers. Its moveable tablet L is fixed at any required elevation by the wooden fcrew M. The piece which forms the foot of this ftand is fixed on the board N; but its relative pofition with regard to the lamp may be changed by fliding the foot of the latter between the pieces OO. P, another ftand for the pneumatic trough. It is raifed or lowered, and fixed to its place, by a ftrong wooden fcrew Q. R is a tube of fafety, or reverfed fyphon, which ferves, in a great meafure, to prevent the bad effects of having the veffels either perfectly clofed, or perfectly open. Suppofe the upper bell-fhaped veffel to be nearly of the fame magnitude as the bulb at the lower end of the tube, and that a quantity of water, or other fuitable fluid, fomewhat lefs than the contents of that veffel, be poured into the apparatus: In this fituation, if the elafticity of the contents of the veffels be lefs than that of the external air, the fluid will defcend in the bulb, and atmofpheric air will follow and pafs through the fluid into the veffels: but, on the contrary, if the elafticity of the contents be greater, the fluid will be either fuftained in the tube, or driven into the bell-fhaped veffel; and if the force be ftrong enough, the gafeous matter will pafs through the fluid, and in part efcape.

Laboratory, || Lacfha.

Fig. 2. Shews the lamp furnace difpofed to produce the faline fufion; the chimney of glafs fhortened; the fupport D turned down; the capfule of platina or filver S placed on the ring very near the flame.

Fig. 3. The fame part of the apparatus, in which, inftead of the capfule, a very thin and fmall crucible of platina T is fubftituted, and refts upon a triangle of iron wire placed on the ring.

Fig. 4. Exhibits the plan of this laft difpofition.

LACERTA, in aftronomy. See ASTRONOMY, n° 406. *Encycl.*

LACMUS, a dye ftuff prepared by the Dutch from the LICHEN ROCELLA, which fee in this *Supplement*.

LACSHA, the Indian name of the lac infect, which has been defcribed in the *Encyclopædia* under the title COCCUS, *Species* 5. Since that article was publifhed, a defcription of that infect, which is more to be depended upon, has been given to the world in the fecond volume of the Afiatic Refearches. It is by Mr Roxburgh, furgeon on the Madras eftablifhment, and was communicated to the Society by Dr James Anderfon phyfician at Fort St George, who obferves, that Mr Roxburgh's difcovery will bring the lacfha as a genus into the clafs *Hemiptera* of Linnæus.

" Some pieces of very frefh-looking lac (fays Mr Roxburgh), adhering to fmall branches of mimofa cinerea, were brought me from the mountains on the 20th of November 1789. I kept them carefully, and today, the 4th of December, fourteen days from the time they came from the hills, myriads of exceedingly minute animals were obferved creeping about the lac, and branches it adhered to, and more ftill iffuing from fmall holes over the furface of the cells: other fmall and perforated excrefcences were obferved with a glafs amongft the perforations, from which the minute infects iffued, regularly two to each hole, and crowned with fome very fine white hairs. When the hairs were rubbed off, two white fpots appeared. The animals, when fingle, ran about pretty brifkly, but, in general, they were fo numerous as to be crowded over one another. The body is oblong, tapering moft towards the tail, below plain, above convex, with a double or flat margin: laterally

Laccha. terally on the back part of the thorax are two fmall tubercles, which may be the eyes: the body behind the thorax is croffed with twelve rings: legs fix; feelers (antennæ) half the length of the body, jointed, hairy, each ending in two hairs as long as the antennæ: rump, a white point between two terminal hairs, which are as long as the body of the animal. The mouth I could not fee. On opening the cells, the fubftance that they were formed of cannot be better defcribed, with refpect to appearance, than by faying it is like the tranfparent amber that beads are made of: the external covering of the cells may be about half a line thick, is remarkably ftrong, and able to refift injuries: the partitions are much thinner: the cells are in general irregular fquares, pentagons and hexagons, about an eighth of an inch in diameter, and one quarter deep: they have no communication with each other. All thofe I opened during the time the animals were iffuing, contained in one half, a fmall bag filled with a thick red jelly-like liquor, replete with what I take to be eggs: thefe bags, or utriculi, adhere to the bottom of the cells, and have each two necks, which pafs through perforations in the external coat of the cells, forming the fore-mentioned excrefcences, and ending in fome very fine hairs. The other half of the cells have a diftinct opening, and contain a white fubftance, like fome few filaments of cotton rolled together, and numbers of the infects themfelves ready to make their exit. Several of the fame infects I obferved to have drawn up their legs, and to lie flat: they did not move on being touched, nor did they fhew any figns of life with the greateft irritation.

"*December* 5. The fame minute hexapedes continue iffuing from their cells in numbers: they are more lively, of a deepened red colour, and fewer of the motionlefs fort. To-day I faw the mouth: it is a flattened point about the middle of the breaft, which the little animal projects on being compreffed.

"*December* 6. The male infects I have found to-day: a few of them are conftantly running among the females moft actively: as yet they are fcarce more, I imagine, than one to 5000 females, but twice their fize. The head is obtufe; eyes black, very large; antennæ clavated, feathered, about $\frac{2}{3}$ds the length of the body: below the middle an articulation, fuch as thofe in the legs: colour betwen the eyes a beautiful fhining green: neck very fhort; body oval, brown: abdomen oblong, the length of body and head: legs fix: wings membranaceous, four, longer than the body, fixed to the fides of the thorax, narrow at their infertions, growing broader for $\frac{2}{3}$ds of their length, then rounded; the anterior pair is twice the fize of the pofterior: a ftrong fibre runs along their anterior margins: they lie flat, like the wings of a common fly when it walks or refts: no hairs from the rump: it fprings moft actively to a confiderable diftance on being touched; mouth in the under part of the head: maxillæ tranfverfe. To-day the female infects continue iffuing in great numbers, and move about as on the 4th.

"*December* 7. The fmall red infects ftill more numerous, and move about as before: winged infects, ftill very few, continue active. There have been frefh leaves and bits of the branches of both *Mimofa Cinerea* and *Corinda* put into the wide mouthed bottle with them: they walk over them indifferently, without fhewing any preference, or inclination to work or copulate. I opened a cell whence I thought the winged flies had come, and found feveral, eight or ten, more in it, ftruggling to fhake off their incumbrances; they were in one of thofe utriculi mentioned on the 4th, which ends in two mouths, fhut up with fine white hairs, but one of them was open for the exit of the flies; the other would no doubt have opened in due time: this utriculus I found now perfectly dry, and divided into cells by exceeding thin partitions. I imagine, before any of the flies made their efcape, it might have contained about twenty. In thefe minute cells with the living flies, or whence they had made their efcape, were fmall dry dark-coloured compreffed grains, which may be the dried excrements of the flies."

Lamanon. LAMANON (Robert Paul), of the Academy at Turin, correfpondent of the Academy of Sciences at Paris, and member of the Mufeum in the fame city, was born at Salon in Provence, in 1752, of an old and refpectable family. Being a younger fon, he was deftined for the church, and fent to Paris to complete his theological ftudies; but getting acquainted with the philofophers (as they called themfelves), he foon loft all relifh for the ftudy of theology, and devoted himfelf to the phyfical fciences, efpecially thofe of chemiftry and mineralogy. Into the church, however, he got, and rofe to the dignity of canon; but by the death of his father and elder brother, having acquired the right of directing his own future exertions, he haftened to quit a profeffion, towards which he felt no partiality.

A prelate, then in high favour at court, hearing of Lamanon's intention of quitting his office of canon, offered him a confiderable fum, to induce him to refign in favour of one of his dependents. The chapter of Arles, replied our young ecclefiaftic, did not fell me my benefice; I fhall therefore reftore it in the fame manner that I received it. This conduct was certainly meritorious; and his eulogift *Ponce* mentions another trait of his character, which fets him in a very amiable point of view; he refufed to accept of his paternal inheritance, otherwife than as an equal fharer with his brothers and fifters.

Thus liberated from the trammels of his former profeffion, Lamanon applied himfelf with uncommon ardour to ftudy. Eager to raife the awful veil that conceals from our eyes the fecrets of Nature; perfuaded, that even the greateft genius only amufes itfelf with falfe fyftems in the filence of a cabinet; convinced of the neceffity of much and various obfervation, and of furprifing Nature as it were in the very fact, in order to penetrate into the fublimity of her operations; — our young philofopher travelled through Provence and Dauphine, and fcaled the Alps and Pyrenees. At the fight of thefe vaft natural laboratories the bent of his mind burft forth inftantaneoufly: he climbed to the fummit of rocks, and explored the abyfs of caverns, weighed the air, analyfed fpecimens, and, in his ardent fancy, having attained the fecrets of creation, he formed a new fyftem of the world. On his return home, he applied with additional intereft to the ftudy of meteorology, mineralogy, natural philofophy, and the other branches of the hiftory of nature.

Whilft he was meditating a vifit to Paris for the purpofe, as his eulogift expreffes himfelf, of converfing with the luminaries of fcience, the inhabitants of the commune of Salon, having loft a caufe againft their lord, unani-

Lamanon. unanimoufly elected Lamanon, with whofe integrity and abilities they were well acquainted, to go and folicit of the council the repeal of an unjuft decree that had been obtained by partiality. The reply of the young philofopher on this occafion is an additional proof of his uncommon difinterefteduefs. "As I intend (faid he) to go to Paris on bufinefs of my own, I cannot think of accepting your offer of 24 livres daily pay: a twelfth of this fum will cover the extraordinary expences of the journeys that I fhall be obliged to make to Verfailles on your account." He had the fatisfaction of complete fuccefs in the bufinefs thus undertaken.

Having fatisfied his curiofity in Paris, he went over to England. During the paffage, though much incommoded by fea-ficknefs, and in imminent hazard of being overwhelmed by the tumbling waves of a very ftormy fea, he caufed himfelf to be tied to the main-maft, in order to contemplate at leifure fo grand and fearful a fpectacle. The burfts of thunder, the howling of the wind, the brilliancy of the lightning, the glancing of the fpray which covered him every moment, thefe objects, fo terrible to an ordinary man, threw him into a kind of mental intoxication, and he has often declared that this day was the moft exquifite of his whole life.

Convinced that the friendfhip of an eminent man elevates the foul, excites generous emulation, and becomes an additional ftimulus to one whofe delight is ftudy, and whofe moft preffing want is an object on which to place his affection, Lamanon anxioufly endeavoured to merit the regard of Condorcet, fo well known by his talents, his impieties, his rebellion, and his misfortunes. This academician, juftly confidering that an apoftate prieft would be ready to join the confpiracy of the philofophifts againft the altar and the throne, received Lamanon with diftinction, and at length admitted him to his moft intimate friendfhip.

During the three fucceffive years that Lamanon fpent at Paris, he followed with care the track of thofe learned focieties, of which he had been elected a member. He became at this period, together with Count de Gebelin, and fome other philofophers and artifts, one of the founders of the Mufeum, the greater part of the members of which are now reunited in the open fociety of fciences, letters, and arts, at Paris. Among the different papers of his that were read at various meetings of thefe focieties, Ponce mentions with particular approbation what he calls *a notice* of Adam de Crapone, an eminent hydraulic engineer; a memoir on the Cretins; a memoir on the theory of the winds; a treatife on the alteration in the courfe of rivers, particularly the Rhone; and another on an enormous bone belonging to fome cetaceous fifh, that was dug up at Paris, in laying the foundations of a houfe in the *Rue Dauphine*. We have not feen thefe memoirs; but as their author was the friend of Condorcet, and fancied that he had attained the fecrets of creation, we can eafily conceive their tendency.

Having refolved again to revifit Switzerland and Italy, Lamanon firft went to Turin, where he allied himfelf to the learned of that country. During his ftay there, the brilliant novelty difcovered by Montgolfier was occupying the attention of all the philofophers of Europe. Lamanon, defirous of making fome experiments of this kind himfelf, afcended in a balloon from the city of Turin; but not perceiving in this difcovery, which had at firft highly interefted him, an object of public utility; not forefeeing, that one day, on the plains of Fleurus, it would be the caufe of rallying and eftablifhing victory under the ftandards of France, he returned to his favourite occupations. Purfuing his route from Piedmont, he vifited Italy, and returned by Switzerland, where he explored the Alps and afcended the fummit of Mont Blanc: thence returning, loaden with the fpoils of the countries which he had traverfed, to Provence, he employed himfelf in the arrangement of the interefting fruits of his journey. Lamanon.

Of the fcrupulous exactnefs of his obfervations, his eulogift gives the following inftance: "Being convinced that the plain of Crau, divided by the channel of the Durance, had formerly been a lake, he wifhed to be abfolutely affured of it. For this purpofe he collected a fpecimen of each of the ftones that are to be found in this vaft plain; the number of thefe he found to amount to nineteen; then tracing the courfe of the river towards its head, near the frontiers of Savoy, he obferved, that above each junction of the tributary ftreams with the Durance, the variety of pebbles diminifhed. Afterwards afcending the current of each of thefe fmaller ftreams, he difcovered on their banks the original rock of every pebble that overfpreads the plain of Crau; thus inconteftably proving, that this plain was anciently a lake formed by the waters of the Durance, and the ftreams that fall into it. If all philofophers (fays our author) would conduct their examinations with equal precifion, certain hypothefes, more brilliant than folid, would not find fo many admirers; the charm of imagination, and the graces of ftyle, would not fo often encroach upon the imprefcriptable rights of nature and truth."

To citizen Ponce this appears a demonftration of Lamanon's theory; but we cannot fay that it does fo to us. It may be a kind of proof, though not a demonftration, that in fome convulfion of nature ftones had been rolled from the rock, and the plain of Crau, for a time, overflowed by the Durance; but it furely furnifhes no evidence of that plain's having ever been *a permanent lake*. It *may* have been fo; but fuch inveftigations as this will not guard philofophers againft the delufions of favourite hypothefes.

It was at the time when Lamanon was preparing for the prefs his great work on the *Theory of the Earth*, that the French government conceived the vaft project of completing the difcoveries of Captain Cook: the academy of fciences was entrufted with the care of felecting men capable of rectifying our notions of the fouthern hemifphere, of improving hydrography, and advancing the progrefs of natural hiftory. Condorcet, not knowing any one better qualified for this laft department than Lamanon, wrote to him an invitation to fhare the danger and glory of this great enterprize. He accepted with eager tranfport a propofal that fulfilled his higheft expectations, haftened to Paris, refufed in a conference with the minifter the falary that was offered, took a hafty leave of his friends, and departed for Breft.

On the 1ft of Auguft 1785, the armament fet fail under the orders of La Peroufe, an experienced commander, whofe patriotifm and fcientific zeal were equal to his courage and good fenfe, and who had already merited the public confidence. The philofophers of all Europe

Lamanon, Lamp.

Europe were in expectation of thofe ufeful difcoveries, the probable fruit of the zeal and talents employed in the expedition. The beginning of the voyage was profperous. After various delays, and a multitude of obfervations, the two veffels arrived at the ifland of Maouna, one of the fouthern Archipelago. The impatient Lamanon, eager to affure himfelf of the truth of the publifhed accounts of that country, debarked with Langle, the fecond in command. At the moment of their return, the natives, in hopes of booty, which had been excited by the number of prefents that they had received, feized upon the boats, and attacked the party. The French were obliged to have recourfe to arms for felf-defence, and a defperate combat enfued. Lamanon, Langle, and ten of the two boats crews, fell a facrifice to the fury of thefe barbarians.

Thus perifhed Lamanon, a young man ardent in the purfuits of fcience, to a high degree difinterefted, and a zealot in what he thought the caufe of liberty. He refufed the falary which was allotted to him when he was appointed to this unfortunate expedition; for "if I do not feel fatisfied (faid he) on board the veffel; if my inclination or curiofity lead me to quit the fhip, — I fhould be unhappy if any power in the world had acquired the right of preventing me."

According to M. Ponce, Lamanon feemed born to bring about a revolution in fcience: the depth of his ideas, the energy of his character, the fagacity of his mind, united to that lively curiofity that can draw inftruction out of any thing, and leaves nothing unexplored, would have led him to the moft valuable difcoveries. In perfon he was tall; and to great vivacity and expreffion of feature added prodigious ftrength and activity; in a word, Nature formed him with fuch care, as if fhe had intended him for one of thofe few who are deftined to great exploits. His ftyle was nervous, often poetical, without lofing fight of propriety, and the language of fentiment might frequently be difcovered in the midft of ftrong and ftriking expreffions; and if he wanted the exquifitely dazzling polifh of diction, he was eminently gifted with the precifion of logical reafoning, which commands attention and enforces perfuafion.

LAMP (fee *Encycl.*) is an inftrument comprifing three articles which demand our attention, *viz.* the oil, the wick, and the fupply of air. It is required that the oil fhould be readily inflammable, without containing any fetid fubftance which may prove offenfive, or mucilage, or other matter, to obftruct the channels of the wick. Mr Nicholfon fays*, that he knows of no procefs by which oils can be meliorated for this purpofe, except that of wafhing with water containing acid or alkali. Either of thefe is faid to render the mucilage of animal oils more foluble in water; but acid is to be preferred, becaufe it is lefs difpofed to combine with the oil itfelf. Perhaps oil might be deprived of all fetid fmell in burning, by being made to pafs through Collier's filtering apparatus, defcribed under the word FILTER in this *Suppl.*

* *Journal*, i. 2.

The office of the wick appears to be chiefly, if not folely, to convey the oil by capillary attraction to the place of combuftion. As the oil is confumed and flies off, other oil fucceeds, and in this way a continued current of oil and maintenance of the flame are effected. But as the wicks of lamps are commonly formed of combuftible matter, it appears to be of fome confequence what the nature and ftructure of this material may be. It is certain that the flame afforded by a wick of rufh differs very confiderably from that afforded by cotton; though perhaps this difference may, in a great meafure, depend on the relative dimenfions of each. And if we may judge from the different odour in blowing out a candle of each fort, there is fome reafon to fufpect that the decompofition of the oil is not effected precifely in the fame manner in each. We have alfo fome obfcure accounts of prepared wicks for lamps, which are ftated to poffefs the property of facilitating the combuftion of very impure oils, fo that they fhall burn for many hours without fmoke or fmell.

Lamp.

The economical wicks of M. Leger, concerning which a report was prefented to the Academy at Paris in 1782 by Condorcet, Lavoifier, and De Milly, were compofed of cotton of different fizes and forms, namely, round and flat, according to the ufe they were intended to ferve. They were covered with a fat fubftance, of a fmell not difagreeable, but feebly aromatic. From the trials of thefe commiffaries it was afcertained: 1. That they afforded a clearer flame, with lefs undulation. 2. That they confumed fomewhat lefs oil; and, 3. That they poffeffed the remarkable property of affording neither fmell nor fmoke, however common the oil made ufe of. When ufing a lamp with a flat wick, we have ourfelves found a piece of clean cotton ftocking anfwer the purpofe better than the cotton wicks which are fold in the fhops.

The accefs of air is of the laft importance in every procefs of combuftion. When a lamp is fitted up with a very flender wick, the flame is fmall, and of a brilliant white colour: if the wick be larger, the combuftion is lefs perfect, and the flame is brown: a ftill larger wick not only exhibits a brown flame, but the lower internal part appears dark, and is occupied by a portion of volatilifed matter, which does not become ignited until it has afcended towards the point. When the wick is either very large or very long, part of this matter efcapes combuftion, and fhews itfelf in the form of coal or fmoke. The different intenfity of the ignition of flame, according to the greater or lefs fupply of air, is remarkably feen by placing a lamp with a fmall wick beneath a fhade of glafs not perfectly clofed below, and more or lefs covered above. While the current of air through the glafs fhade is perfectly free, the flame is white; but in proportion as the aperture above is diminifhed, the flame becomes brown, long, wavering, and fmoky; it inftantly recovers its original whitenefs when the opening is again enlarged. The inconvenience of a thick wick has been long fince obferved, and attempts made to remove it; in fome inftances, by fubftituting a number of fmall wicks inftead of a larger; and in others, by making the wick flat inftead of cylindrical. The moft fcientific improvement of this kind, though perhaps lefs fimple than the ordinary purpofes of life demand, is the well known lamp of Argand, defcribed in the *Encyclopædia*.

Much has been faid of this lamp, and great praife lavifhed on the inventor. It cannot indeed be denied that it was a very pretty invention, nor have we the flighteft wifh to detract from the merit of M. Argand; but truth compels us to fay, that the fame thought had occurred to others as early as to him, and that lamps had

Lamp. had been constructed on his principles long before he had published an account of his lamp to the world (A).

Many ingenious men have endeavoured to determine the most economical method of lighting up large halls and workhouses by means of different lamps and candles; and when the expence of tallow and oil is considered, it will be admitted that they could not employ their time in a manner more beneficial to the poor and the industrious. Among others, Count Rumford and M. Hassenfratz have turned their attention to this subject; and the results of their investigations are worthy of notice. To the Count, a method occurred for measuring the relative quantities of light emitted by lamps of different constructions, which is at once simple and accurate. It is as follows:

Let the two burning lamps, or other lights to be compared, be called A and B; and let them be placed at equal heights upon two light tables, or moveable stands, in a darkened room; let a sheet of clean white paper be equally spread out, and fastened upon the wainscot, or side of the room, at the same height from the floor as the lights; and let the lights be placed overagainst this sheet of paper, at the distance of six or eight feet from it, and six or eight feet from each other, in such a manner, that a line drawn from the centre of the paper, perpendicular to its surface, shall bisect the angle formed by lines drawn from the lights to that centre; in which case, considering the sheet of paper as a plane speculum, the one light will be precisely in the line of reflection of the other.

This may be easily performed, by actually laying a piece of a looking-glass, six or eight inches square, flat upon the paper, in the middle of it; and observing, by means of it, the real lines of reflection of the lights from that plane, removing it afterwards, as soon as the lights are properly arranged. When this is done, a small cylinder of wood, about one-fourth of an inch in diameter, and six inches long, must be held in a vertical position, about two or three inches before the centre of the sheet of paper, and in such a manner, that the two shadows of the cylinder, corresponding to the two lights, may be distinctly seen upon the paper.

If these shadows should be found to be of unequal densities, which will almost always be the case, then that light whose correspording shadow is the densest must be removed farther off, or the other must be brought nearer to the paper, till the densities of the shadows appear to be exactly equal; or, in other words, till the densities of the rays from the two lights are equal *at the surface of the paper;* when, the distances of the lights from the centre of the paper being measured, the squares of those distances will be to each other as the real intensities of the lights in question at their sources.

If, for example, the weaker light being placed at the distance of four feet from the centre of the paper, it should be found necessary, in order that the shadows may be of the same density, to remove the stronger light to the distance of eight feet from that centre, in that case, the real intensity of the stronger light will be to that of the weaker as 8^2 to 4^2; or as 64 to 16; or 4 to 1; and so for any other distances.

It is well known, that when any quality proceeds from a centre in straight lines in all directions, like the light emitted by a luminous body, its intensity at any given distance from that centre will be as the square of that distance inversely; and hence it is clear, that the intensities of the lights in question, at their sources, must be to each other as the squares of their distances from that given point *where their rays uniting are found to be of equal density.* For, putting $x =$ the intensity of B, if P represents the point where the rays from A and from B meeting are found to be of equal density or strength, and if the distance of A from P be $= m$, and the distance of B from the same point P $= n$; then, as the intensity of the light of A at P is $= \frac{x}{m^2}$, and the intensity of the light of B at the same place $= \frac{y}{n^2}$, and as it is $\frac{x}{m^2} = \frac{y}{n^2}$ by the supposition, it will be $x : y :: m^2 : n^2$.

That the shadows being of equal density at any given point, the intensities of the illuminating rays must of necessity be equal at that point also, is hence evident that the total absence of light being perfect blackness, and the shadow corresponding to one of the lights in question being deeper or fainter, according as it is more or less enlightened by the other, when the shadows are equal, the intensities of the illuminating rays must be equal likewise.

In removing the lights, in order to bring the shadows to be of the same density, care must be taken to recede from, or advance towards, the centre of the paper in a straight line, so that the one light may always be found exactly in the line of reflection of the other; otherwise the rays from the different lights falling upon the paper, and consequently upon the shadows, at different angles, will render the experiment fallacious.

When the intensity of one strong light is compared with the intensities of several smaller lights taken together, the smaller lights should be placed in a line perpendicular to a line drawn to the centre of the paper, and as near to each other as possible; and it is likewise necessary to place them at a greater distance from the paper than when only single lights are compared.

In all cases, it is absolutely necessary to take the greatest care that the lights compared be properly trimmed, and that they burn clear and equally, otherwise the results of the experiments will be extremely irregular and inconclusive. It is astonishing what a difference there is in the quantities of light emitted by the same candle, when it burns with its greatest brilliancy, and when it has grown dim for want of snuffing. But as this diminution of light is progressive, and as the eye insensibly conforms to the quantity of light actually present, it is not always taken notice of by the spectators; it is nevertheless very considerable, in fact, as will be apparent to any one who will take the trouble to make the experiment; and so great is the fluctuation in the quantity of light emitted by burning bodies, lamps, or candles, in all cases, even under the most favourable circumstances, that this is the source of the greatest difficulties which our author met with in determing the relative

(A) One of these was employed in the college of Glasgow, by the lecturer on chemistry, so long ago as 1766.

Lamp. relative intenſities of lights by the method here propoſed.

To aſcertain by this method the comparative denſities, or intenſities, of the light of the moon and of that of a candle, the moon's direct rays muſt be received upon a plane white ſurface, at an angle of incidence of about 60°, and the candle placed in the line of the reflection of the moon's rays from this ſurface; when the ſhadows of the cylinder, correſponding to the moon's light and to that of the candle, being brought to be of equal denſity, by removing the candle farther off, or bringing it nearer to the centre of the white plane, as the occaſion may require, the intenſity of the moon's light will be equal to that of the candle *at the given diſtance of the candle from the plane.*

To aſcertain the intenſity of the light of the heavens, by day or by night, this light muſt be let into a darkened room through a long tube blackened on the inſide, when its intenſity may be compared with that of a candle or lamp by the method above deſcribed.

The Count, however, has contrived an apparatus for aſcertaining the intenſity of the ſun's light, compared with the light emitted by any artificial illuminator, with much greater accuracy than it can be done by this ſimple method. That apparatus we ſhall deſcribe under the title PHOTOMETER in this *Supplement*; and in the mean time we proceed to lay before our readers the reſults of his experiments as they relate to economy in the production of artificial light.

1
Of the relative quantities of oil conſumed, and of light emitted, by an Argand's lamp, and by a lamp in the common conſtruction, with a riband wick.

The brilliancy of Argand's lamp is not only unrivalled, but the invention is in the higheſt degree ingenious, and the inſtrument uſeful for many purpoſes; but ſtill, to judge of its real merits as an illuminator, it was neceſſary to know whether it gives more light than another lamp *in proportion to the oil conſumed.* This point he determined in the following manner:

Having placed an Argand's lamp, well trimmed, and burning with its greateſt brilliancy, before his *photometer*, and over againſt it a very excellent common lamp, with a riband wick about an inch wide, and which burnt with a clear bright flame, without the leaſt appearance of ſmoke, he found the intenſities of the light emitted by the two lamps to be to each other as 17956 to 9063; the denſities of the ſhadows being equal when, the Argand's being placed at the diſtance of 134 inches, the common lamp was placed at the diſtance of 95,2 inches, from the field of the photometer.

Both lamps having been very exactly weighed when they were lighted, they were now (without being removed from their places before the photometer) cauſed to burn with the ſame brilliancy juſt 30 minutes; they were then extinguiſhed and weighed again, and were found to have conſumed of oil, the Argand's lamp $\frac{253}{8192}$, and the common lamp $\frac{163}{8192}$, of a Bavarian pound.

Now, as the quantity of light produced by the Argand's lamp, in this experiment, is to the quantity produced by the common lamp as 17956 to 9063, or as 187 to 100, while the quantity of oil conſumed by the former is to that conſumed by the latter only in the ratio of 253 to 163, or as 155 to 100, it is evident that the quantity of light produced by the combuſtion of a given quantity of oil in an Argand's lamp is greater than that produced by burning the ſame quantity in a common lamp, in the ratio of 187 to 155, or as 100 to 85.

The ſaving, therefore, of oil which ariſes from making uſe of an Argand's lamp inſtead of a common lamp, in the production of light, is evident; and it appears, from this experiment, that that ſaving cannot amount to leſs than fifteen *per cent.* How far the advantage of this ſaving may, under certain circumſtances, be counterbalanced by inconveniences that may attend the making uſe of this improved lamp, our author does not pretend to determine.

2
Of the relative quantities of light emitted by an Argand's lamp and by a common wax candle.

The Count made a conſiderable number of experiments to determine the relative quantities of light emitted by an Argand's lamp and a common wax-candle; and the general reſult of them is, that a common Argand's lamp, burning with its uſual brightneſs, gives about as much light as nine good wax-candles; but the ſizes and qualities of candles are ſo various, and the light produced by the ſame candle ſo fluctuating, that it is very difficult to aſcertain, with any kind of preciſion, what a common wax-candle is, or how much light it ought to give. He once found that his Argand's lamp, when it was burning with its greateſt brilliancy, gave twelve times as much light as a good wax-candle $\frac{3}{4}$ths of an inch in diameter, but never more.

3
Of the fluctuations of the light emitted by candles.

To determine to what the ordinary variations in the quantity of light emitted by a common wax-candle might amount, he took ſuch a candle, and, lighting it, placed it before the photometer, and over againſt it an Argand's lamp, which was burning with a very ſteady flame; and meaſuring the intenſity of the light emitted by the candle from time to time, during an hour, the candle being occaſionally ſnuffed when it appeared to ſtand in need of it, its light was found to vary from 100 to about 60. The light of a wax-candle of an inferior quality was ſtill more unequal; but even this was but trifling, compared to the inequalities of the light of a tallow-candle.

An ordinary tallow-candle, of rather an inferior quality, having been juſt ſnuffed, and burning with its greateſt brilliancy, its light was as 100; in eleven minutes it was but 39; after eight minutes more had elapſed, its light was reduced to 23; and in ten minutes more, or twenty-nine minutes after it had been laſt ſnuffed, its light was reduced to 16. Upon being again ſnuffed, it recovered its original brilliancy, 100.

4
Of the relative quantities of bees-wax, tallow, olive-oil, rape-oil, and linſeed-oil, conſumed in the production of light.

In order to aſcertain the relative quantities of bees wax and of olive-oil conſumed, in the production of light, the Count proceeded in the following manner: Having provided an end of a wax-candle of the beſt quality, ,68 of an inch in diameter, and about four inches in length, and a lamp with five ſmall wicks, which he had found upon trial to give the ſame quantity of light as the candle, he weighed very exactly the candle and the lamp filled with oil, and then, placing them at equal diſtances (forty inches) before the field of the photometer, he lighted them both at the ſame time; and, after having cauſed them to burn with preciſely the ſame degree of brightneſs *juſt one complete hour*, he extinguiſhed them both, and, weighing them a ſecond time, he found that 100 parts of wax and 129 parts of oil had been conſumed.

Hence it appears, that the conſumption of bees-wax is to the conſumption of olive-oil, in the produc-

tion

Lamp. tion of the fame given quantity of light, as 100 is to 129.

In this experiment no circumftance was neglected that could tend to render the refult of it conclufive; care was taken to fnuff the candle very often with a pair of fharp fciffars, in order to make it burn conftantly with the fame degree of brilliancy; and the light of the lamp was, during the whole time, kept in the moft exact equilibrium with the light of the candle, which was eafily done by occafionally drawing out, a little more or lefs, one or more of its five equal wicks. Thefe wicks, which were placed in a right line, perpendicular to a line drawn from the middle wick to the middle of the field of the photometer, were about $\frac{1}{10}$th of an inch in diameter each, and $\frac{1}{4}$th of an inch from each other; and, when they were lighted, their flames united into one broad, thin, and very clear, white flame, without the leaft appearance of fmoke.

In order to afcertain the relative confumption of olive-oil and rape-oil, in the production of light, two lamps, like that juft defcribed, were made ufe of; and, the experiment being made with all poffible care, the confumption of olive-oil appeared to be to that of rape-oil, in the production of the fame quantity of light, as 129 is to 125.

The experiment being afterwards repeated with olive-oil and very pure linfeed oil, the confumption of olive-oil appeared to be to that of linfeed oil as 129 to 120.

The experiment being twice made with olive-oil and with a tallow-candle; once when the candle, by being often fnuffed, was made to burn conftantly with the greateft poffible brilliancy, and once when it was fnuffed to burn the whole time with a very dim light, owing to the want of fnuffing; the refults of thefe experiments were very remarkable.

When the candle burnt with a clear bright flame, the confumption of the olive-oil was to the confumption of the tallow as 129 is to 101; but when the candle burnt with a dim light, the confumption of the olive-oil was to the confumption of the tallow as 129 is to 229. So that it appeared, from this laft experiment, that the tallow, inftead of being nearly as productive of light in its combuftion as bees-wax, as it appeared to be when the candle was kept conftantly well fnuffed, was now, when the candle was fuffered to burn with a dim light, by far lefs fo than oil.

But this is not all; what is ftill more extraordinary is, that the very fame candle, burning with a long wick, and a dim light, actually confumed *more tallow* than when, being properly fnuffed, it burnt with a clear bright flame, and gave near *threee times as much light.*

To be enabled to judge of the relative quantities of light actually produced by the candle in the two experiments, it will fuffice to know, that in order to counterbalance this light at the field of the *photometer*, it required, in the former experiment, the confumption of 141 parts, but in the latter only the confumption of 64 parts, of olive oil. But in the former experiment 110, and in the latter 114, parts of tallow were actually found to be confumed. Thefe parts were 8192ths of a Bavarian pound.

From the refults of all the foregoing experiments, it appears that the relative expence of the undermentioned inflammable fubftances, in the production of light, is as follows:

		Equal Parts in Weight.
Bees-wax.	A good wax-candle, kept well fnuffed, and burning with a clear bright flame, . . .	100
Tallow.	A good tallow-candle, kept well fnuffed, and burning with a bright flame, ...	101
	The fame tallow-candle, burning very dim for want of fnuffing,	229
Olive-oil.	Burnt in an Argand's lamp, . .	110
	The fame burnt in a common lamp, with a clear bright flame, without fmoke, ...	129
Rape oil.	Burnt in the fame manner, . .	125
Linfeed-oil.	Likewife burnt in the fame manner, ...	120

With the foregoing table, and the prices current of the therein mentioned articles, the relative prices of light produced by thofe different materials may very readily be computed.

In the year 1795, Mr J. H. Haffenfratz was employed by the French government to make a feries of experiments to determine the moft economical method of procuring light from the different combuftible fubftances ufually employed for that purpofe. The materials of his experiments were, wax, fpermaceti, and tallow-candles, fifh-oil, oil of colefeed, and of poppy-feeds. In ufing thefe oils, both the Argand and common lamps were employed. The wicks of the latter were round, containing thirty-fix cotton threads. The tallow and fpermaceti candles were mould, fix to the pound. The wax-candles five to the pound. Mr Haffenfratz ufed the fame method with Count Rumford for determining the comparative intenfity of the lights.

Count Rumford, as we have feen, ufed the Argand lamp as a ftandard for comparifon; but as the intenfity of its light varies according to the height of the wick, Mr Haffenfratz preferred a wax-candle, making ufe of it foon after it was lighted. When two luminous bodies, of different intenfities, are put in comparifon with each other, the fhadows are of two colours. That from the weakeft light is blue, and from the ftrongeft, red. When the lights of two different combuftible bodies are compared, they are either red or blue in a compound ratio of the colour and intenfity. Thus in comparing the fhadows from different luminous bodies, they will be red or blue refpectively, in the following order:

Light of the fun,
—— of the moon,
—— of Argand lamps,
—— of tallow-candles,
—— of wax ditto,
—— of fpermaceti ditto,
—— of common lamps.

That is to fay, when a body is illuminated by the fun and by any other luminous fubftance, the fhadow of the former is red, and of the latter, blue. In like manner, the fhadow from an Argand lamp is red, when placed by that of a tallow-candle, which is blue.

The following table will fhew, according to Mr Haffenfratz, the proportional diftance that different luminous bodies fhould be placed at to produce an equally intenfe fhadow from the fame object. The fecond column gives

gives the proportional intenfity of each light, which is known to be in proportion to the fquares of the diftances of luminous bodies giving the fame depth of fhadow. The third column fhews the quantity of combuftible matter confumed in the hour by each mode of giving light, which Mr Haffenfratz calculates from the average of many repeated experiments.

	Diftance.	Intenfity.	Quantity confumed per hour.	Quantity required for equal intenfities.
Argand lamps with oil of poppyfeed	10	10.000	23	23
— of fifhes	10	10.000	23.77	23.77
— of colefeed	9.246	8.549	14.18	16.59
Common lamps with oil of colefeed	6.774	4.588	8.81	19.2
— of fifhes	6.524	4.556	9.14	20.06
— of poppyfeed	5.917	3.501	7.05	20.14
Spermaceti candle	5.917	3.501	9.23	26.37
Old tallow candle	5.473	2.995	[illegible].54	25.17
New ditto	5.473	2.995	8.23	27.48
Wax candle	4.275	1.827	9.54	53

The relative quantity of combuftible matter required to produce *equal* lights at equal diftances, may be obtained by a fimple rule of proportion from the above data. Thus, if a given intenfity of light, expreffed by 3.501, has been produced by a confumption of 9.23 of fpermaceti in the hour, the fame luminous body will produce a light of 10.000, by confuming in the fame time a quantity of fpermaceti $= \frac{10.000 \times 9.23}{3.501} = 26.37$. Therefore we may add to the table a fourth column, expreffing the quantity of combuftible which each body muft confume to produce a light of 10.000.

From what has been laid down, it will alfo appear that the number of lights required to produce a given light, will be as follows: To produce a light equal to 100 Argand lamps, burning poppyfeed oil, it will require

100 Argand lamps with fifh-oil
117 Ditto do. with colefeed oil
218 Common lamps with colefeed oil
219 Ditto do. with fifh oil
285 Ditto do. with poppyfeed oil
285 Spermaceti candles
333 Tallow ditto
546 Wax ditto.

Mr Haffenfratz next takes notice of the comparative price of thefe articles; by which he finds, that in Paris the moft expenfive light is that produced from wax-candles; and the moft *economical* that from oil of colefeed burned in Argand lamps.

The chief difference between the Argand and common lamp is, that in the latter much of the oil is volatilized without combuftion, and hence the unpleafant fmell which it produces; whereas in the former, the heat is fo great at the top of the wick, that all the oil is decompofed in paffing through, the difpofition of the wick allowing the free accefs of air to affift combuftion. It fhould therefore follow, that the Argand lamp confumes lefs fuel to produce a given light than the common lamp, and this, as we have feen, is the opinion of Count Rumford. Yet (Mr Haffenfratz obferves) there are two circumftances that prevent the full effect of the complete combuftion in the Argand lamp. The one is, that the glafs cylinder abforbs a part of the rays of light as they pafs through; the other, that the column of light proceeding from the inner furface of the wick, is, in part, loft, by being obliged to pafs through that from the outer furface. Count Rumford allows the firft caufe of diminution of light, and eftimates it at .1854, but not the latter. The author of this memoir, in repeating Count Rumford's experiments, afferts, that when two candles are placed fo that the light of the one is obliged to pafs through that of the other, the fum of the light fo produced is not fo ftrong as when they are placed fide by fide; for in the firft cafe, a part of the hindmoft light is abforbed by the foremoft.

LANCASHIRE. In the account which we have given of that county in the *Encyclopædia*, an obliging correfpondent has pointed out to us fome miftakes. He affures us that the fea-coaft, where we underftood the atmofphere to be loaded with fuch exhalations as produce malignant and intermitting fevers, is remarkably healthy; and he fpeaks from experience, having lived on that coaft for forty years. He affures us likewife, that the Duke of Bridgewater's inland navigation was begun foon after, if not before, the year 1736, and that he (the writer), fo early as 1764, was one of a party who failed up the fough or edit a confiderable way to fee how the coals were worked. The fame correfpondent has pointed out a few miftakes in our account of

LANCASTER, the capital of the county. "That town (he fays) carries on no trade whatever with North America, but a very confiderable one with Jamaica and the other Weft India iflands, in veffels of from 100 to 500 tons burthen. It exports to thefe iflands all fuch Britifh manufactures as they have occafion for, Irifh linens, and falted provifions of all kinds, fuch as Irifh beef, pork, butter, &c. It trades alfo to the Baltic, Portugal, Hamburgh, &c. to a large amount; and fome of its fhips with their cargoes have of late been worth from L.60 to L.80,000 fterling. It has, however, no communication by water with the rivers Merfey, Dee, &c. as we have faid; the canal reaching as yet no farther than to near Prefton in Lancafhire." The communication with thefe rivers is indeed intended to be completed; but whether the fcheme be practicable is, according to our correfpondent, very uncertain.

LANTERN. See *Encycl.*—Sir George Staunton informs us, that of the Chinefe lanterns, fome were fuch as we have defcribed, viz. compofed of thin filk gauze, painted or wrought in needlework with figures of birds, infects, flowers, or fruit, and ftretched on neat frames of wood. Others, however, were very different, being entirely made of horn. Thefe were fo thin and tranfparent, that they were taken at firft for glafs; a material to which, for this purpofe, the horn is preferred by the Chinefe, as cheaper, lighter, lefs liable to accident, and, in cafe of accident, more eafily repaired; many of them were about two feet in the diameter, and in the form of a cylinder, with the ends rounded off, and the edges meeting in the point to which the fufpending cords were tied. Each lantern confifted of an uniform piece of horn, the joints, or feams, being rendered invifible

Lantern. visible by an art found out by the Chinese; among whom, the vast number of such lanterns used in their dwelling houses and temples, as well as on the occasions of their festivals and processions, have led to many trials for improving their construction. The horns generally employed are those of sheep and goats. The usual method of managing them, according to the information obtained upon the spot, is to bend them by immersion in boiling water, after which they are cut open and flattened; they then easily scale, or are separated into two or three thin laminæ or plates. In order that these plates should be made to join, they are exposed to the penetrating effect of steam, by which they are rendered almost perfectly soft. In this state the edges of the pieces to be joined are carefully scraped and slanted off, so as that the pieces overlapping each other shall not together exceed the thickness of the plate in any other part. By applying the edges, thus prepared, immediately to each other, and pressing them with pincers, they intimately adhere, and, incorporating, form one substance, similar in every respect to the other parts; and thus uniform pieces of horn may be prepared to almost any extent. It is a contrivance little known elsewhere, however simple the process appears to be; and perhaps some minute precautions are omitted in the general description, which may be essential to its complete success.

Such lanterns as these would be very proper for military store-houses; and Rochon of *the National Institute* was employed, since the commencement of the present war, to make them, if he could, for the marine store-houses of France. While he was thus engaged, however, it occurred to him that he might supply the pressing wants of the navy without horn, merely by filling up the interstices of wirecloth with fine transparent glue. In carrying this thought into execution, he at first tinned the iron wires of the sieve-cloth he made use of; but afterwards found it more convenient, in every respect, to give it a slight coating of oil paint to preserve it from rust. The glue he made use of was afforded by boiling the clippings of parchment with the air-bladders and membranes of sea-fish; materials which he used, not from any notion that they were preferable to isinglass, but because they were the cheapest he could procure. He added the juice of garlic and cyder to his composition, in such proportions as he found to communicate great tenacity, and somewhat more of transparence than it would have possessed without them. Into this transparent and very pure glue or size he plunged his wire-cloth, which came out with its interstices filled with the compound. It is requisite that the size should possess a determinate heat and consistence, concerning which experience alone must guide the operator.

When this prepared wire-cloth is fixed in the lantern, it must be defended from moisture by a coating of pure drying linseed oil; but even in this state it is not fit to be exposed to the weather. The ease with which these lanterns are repaired in case of accident, by a slight coating of glue, is pointed out as a great advantage by the inventor; who likewise informs us, that they were used in the expedition to Ireland as signal-lanterns, though contrary to his wishes.

LAPIS Fungifer, a species of earth found near Rome, Naples, and Florence, of which the following account is taken from the *New Transactions of the Royal Academy of Sciences at Stockholm* for the year 1797: Near Naples the lapis fungifer is found in the chalk-hills like a white stalactites, intermixed with a great many fine roots of shrubs; and near Florence there is a species of it, consisting of hardened turf, which is dug up near volcanoes. The author made experiments with a piece procured from Italy, and found that 100 parts contain from 45 to 46 siliceous earth, 23 argillaceous earth, 7 calcareous earth, and 20 calx of iron, with some white magnesia and vegetable alkali. It is well known, that when this friable species of stone is preserved in cellars and moistened with water, it produces abundance of eatable mushrooms, which in Italy are highly esteemed and brought to the first tables. Hence the origin of its name.

Lardizabala.

LARDIZABALA, a new genus of plants belonging to the *diœcia hexandria* of Linnæus. It is a native of Chili, and is thus described in Perouse's Voyage, from drawings sent to France by La Martiniere. The leaves are alternate, on footstalks inflated at their base. Each leaf is biternate, that is to say, it is divided into three leaflets, each of which is again subdivided into three oval sharp-pointed folioles, which, when young, are entire, but afterwards become obscurely lobed The flowers, disposed in simple and pendent clusters, grow towards the top of the stem and of the branches, in the axillæ of the leaves. The plant is diœcius. At the base of each cluster of blossoms are two small, rounded, oval, floral leaves.

Male Flower.—*Calyx* formed of six expanding leaves, oblong oval, and obtuse, of which the three outermost are the largest. *Corolla* composed of six sharp lanceolated petals, opposite to, and shorter than, the leaves of the calyx. A cylinder rises from the centre of the flower of the length of the petals, terminated by six oblong bilocular anthers, which open from below.

Female Flower.—*Calyx*, similar to that of the male flower, but larger. *Corolla* inserted beneath the pistil, composed of six petals, rarely entire, but generally bifid or trifid at their summit: shorter than the leaves of the calyx. *Stamina* six, having the same insertion as the corolla; filaments distinct, broad, very short, surrounding the pistil; *anthers*, six, upright, oblong, acuminated, barren. *Seed bud*, cells, from three to six, oblong, gibbous on the outside, of nearly the length of the corolla; styles none; stigmata, sitting, oblong, permanent. *Berries*, equal in number to the cells, oblong, acuminated (divided into six cells, containing several angular seeds. *Flora Peruviana*).

The general character of the lardizabala evidently places this new genus among the family of the *menispermæ*, to which it is related by its climbing stalk, its bunches of diœcious flowers, by its six petals, stamina, and leaves of its calyx, by its pistil, composed of from three to six cells, which contain as many seeds. It differs from the known genera of this order only in its fruit, which, instead of being monospermous, contains several seeds. This character, which requires the introduction of a new section into the *menispermæ*, strengthens the relation of this family to the next order of the *anonæ*. In fact, the greater part of the genera of the anonæ, as they have in the same flower several fruits, with numerous seeds, differ in this particular from all the genera of the menispermæ; and by placing between them the lardizabala, we establish a natural transition.

tranſition. In order to confirm theſe reſemblances, it only remains to examine the inſide of the fruit, and particularly the ſtructure of the ſeeds. Thoſe of the meniſpermæ are reniform, at leaſt on the inſide, incloſed in a hinged pericarpium, and containing in their upper part a very ſmall dicotyledonus embryo. The characters that we have given of the lardizabala render probable a ſimilar ſtructure in its ſeeds.

LARMIER, in architecture, a flat ſquare member of the cornice below the cimaſium, and jets out fartheſt; being ſo called from its uſe, which is to diſperſe the water, and cauſe it to fall at a diſtance from the wall, drop by drop, or, as it were, by tears, *larme* in French ſignifying a tear.

LATUS Primarium, a right line drawn through the vertex of the ſection of a cone, within the ſame, and parallel to the baſe.

Latus Rectum. See *Conic Sections*. Encycl.

Latus Tranſverſum of the hyperbola, is the right line between the vertices of the two oppoſite ſections, or that part of their common axis lying between the two oppoſite cones.

LAVA. In addition to the obſervations of Sir William Hamilton, Bergman, Formes, and Dalmieu, on the compoſition of different lavas, which have been given in the *Encyclopædia*, we cannot refuſe ourſelves the pleaſure of noticing, in this place, thoſe of Sir James Hall. From a number of well-deviſed experiments, Sir James thinks himſelf warranted to conclude, that lava and whinſtone are intrinſically the ſame ſubſtance; and that their apparent differences ariſe wholly from the circumſtances under which they have paſſed from a liquid to a ſolid ſtate. The lavas, it is well known, have been cooled rapidly in the open air, and the whins (according to Dr Hutton's theory, which Sir James ſeems willing to adopt) ſlowly in the bowels of the earth.

Though we are far from adopting that theory in all its parts, to which we think inſuperable objections may be made (ſee Earth, *Encycl.* n° 120), we admit, that the experiments of Sir James Hall go far to eſtabliſh the identity of lava and whinſtone. Theſe experiments were made upon ſeven different ſpecies of whinſtone and ſix lavas, of which four were broken from the currents of Etna and Veſuvius by Sir James himſelf. Each of the original whinſtones was reduced, by fuſion and ſubſequent rapid cooling, to a ſtate of perfect glaſs. This glaſs, being again placed in the furnace, was ſubjected to a ſecond fuſion. The heat, being then reduced to a temperature generally about 28° of Wedgewood, was maintained ſtationary for ſome hours; when the crucible was either immediately removed, or allowed to cool with the furnace. The conſequence was, that in every caſe the ſubſtance had loſt the character of glaſs, and by cryſtallization had aſſumed in all reſpects that of an original whinſtone. It muſt be owned, that in moſt caſes the new production did not exactly reſemble the particular original from which it was formed, but ſome other original of the ſame claſs; owing to accidental varieties in the mode of refrigeration, and to chemical changes which unavoidably took place during the proceſs. In the caſe, however, of the rock of Edinburgh caſtle, and of that of the baſaltic columns of Staffa, the artificial ſubſtances bear a complete reſemblance to their originals, both in colour and texture.

The lavas were now treated in the ſame way, and were each, by fuſion and rapid cooling, reduced, as the whinſtones had been, to glaſs. This glaſs, when fuſed again and cooled ſlowly, yielded the ſame kind of cryſtallized, ſtony, or earthy maſſes, completely reſembling an original whin or lava.

Although the internal ſtructure of lava was thus accounted for, yet Sir James was embarraſſed with the ſtate of its external ſurface; which, though cooled in contact with the open air, is ſeldom or never vitreous, holding an intermediate ſtation between glaſs and ſtone; but this difficulty was removed by a circumſtance which took place in the courſe of theſe experiments. It was found that a ſmall piece of glaſs of any of the lavas, or of ſeveral of the whins being introduced into a muffle, the temperature of which was at any point between the 20th and the 22d degree of Wedgewood's ſcale, the glaſs became quite ſoft in the ſpace of one minute; but, being allowed to remain till the end of a ſecond minute, it was found to have become hard throughout in conſequence of a rapid cryſtallization, to have loſt its character of glaſs, and to have become by 12 or 14 degrees more infuſible, being unaffected by any heat under 30, though the glaſs had been fuſible at 18° or at 16°. This accounted for the ſcoria on the ſurface of lavas; for the ſubſtance even at the ſurface, being in contact with the flowing ſtream, and ſurrounded with heated air, could not cool with exceſſive rapidity: and the experiment ſhews, that ſhould any part of the maſs, in deſcending heat, employ more than one or two minutes in cooling from 22 to 20, it would infallibly loſe its vitreous character.

Independently of any alluſion to ſyſtem or to general theory, Sir James Hall flatters himſelf that theſe experiments may be of ſome importance, by ſimplifying the hiſtory of volcanoes; and, above all, by ſuperſeding ſome very extraordinary, and, he conceives, unphiloſophical opinions advanced with regard to volcanic heat, which has been ſtated as poſſeſſing very little intenſity, and as acting by ſome ocult and inconceivable influence, or with the help of ſome inviſible agent, ſo as to produce liquidity without fuſion. Theſe ſuppoſitions, which have been maintained ſeriouſly by ſome of the moſt celebrated naturaliſts in Europe, have originated from the difficulty of accounting for the ſtony character of lavas when compared with that of glaſs, which they aſſume in conſequence of fuſion in our furnaces. But now he hopes we may be relieved from the neceſſity of ſuch violent efforts of imagination, ſince the phenomena have been fully accounted for by the ſimple, though unnoticed, principle of refrigeration, and have been repeated again and again with eaſe and certainty in a ſmall chamber furnace.

LAVOISIER (Antoine Laurent), was born in Paris on the 26th of Auguſt 1743. His father, who directed his education, was opulent, and ſpared no coſt for his improvement. The youth ſhewed a decided taſte for the phyſical ſciences. In 1764, government having propoſed an extraordinary premium for the beſt and cheapeſt mode of lighting the ſtreets of a large city, Lavoiſier obtained the gold medal; and his memoir, full of nice inveſtigation, was printed by the Academy. Into that body he was received on the 13th May 1768, in ſpite of a formidable oppoſition; and to its ſervice he ever after devoted his labours, and became one of its moſt uſeful aſſociates and coadjutors.

His

Lavoifier. His attention was fucceffively occupied with every branch of phyfical and mathematical fcience. The pretended converfion of water into earth, the analyfis of gypfum in the neighbourhood of Paris, the cryftallization of falts, the effects produced by the *grande de loupe* of the garden of the Infanta, the project of bringing water from l'Yvette to Paris, the congelation of water, and the phenomena of thunder and the aurora borealis—all occupied his attention.

Journeys, undertaken in concert with Guettard into every diftrict of France, enabled him to procure numberlefs materials towards a defcription of the lithological and mineralogical empire; thefe he arranged into a kind of chart, which wanted little of being completed. They ferved alfo as a foundation for a more laborious work of his on the revolutions of the globe, and the formation of *Couches de la Terre;* a work of which two beautiful fketches are to be feen in the Memoirs of the French Academy for 1772 and 1787. All the fortune and all the time of Lavoifier were devoted to the culture of the fciences; nor did he feem to have a preponderating inclination for any one in particular, until an event, fuch as feldom occurs in the annals of the human mind, decided his choice, and attached him thenceforth exclufively to chemiftry—a purfuit which has fince rendered his name immortal.

The important difcovery of gafes was juft announced to the philofophical world. Black, Prieftley, Scheele, Cavendifh, and Macbride, had opened to phyfiologifts a fort of new creation; they had commenced a new era in the annals of genius, which was to become equally memorable with thofe of the compafs, printing, electricity, &c.

It was about the year 1770 that Lavoifier, ftruck with the importance and grandeur of this difcovery, turned his attention to this inexhauftible fountain of truths, and inftantly perceived, by a kind of inftinct, the glorious career which lay before him, and the influence which this new fcience would neceffarily have over the whole train of phyfical refearches. Of thofe who had preceded him, the moft indefatigable experimenter was Prieftley: but facts the moft brilliant remained frequently unproductive in his hands: on every occafion he was ready to frame fome crude hypothefis, which as haftily he abandoned. Lavoifier was imbued with the true fpirit of inductive philofophy; his obfervations, eminently precife and luminous, always pointed to general views. In 1774, he publifhed his chemical opufcules, which contained a very neat hiftory of all that had been done with refpect to gafes, and concluded with the author's capital experiments, by which it was proved, that metals, in calcination, derive their augmentation of weight from the abforption of air. Soon afterward, he fhewed, in oppofition to Prieftley, that nitrous acid is compofed of air; a remark, of which the importance appeared in the fequel. His ingenuity as a chemift was now fo well known, that in 1776 Turgot employed him to infpect the manufacture of gun-powder. He introduced fome valuable improvements, and, fuppreffing the odious vifits in queft of the materials of faltpetre, he yet quintupled its produce. The gun-powder would now carry 120 toifes, when formerly it would not reach 90. This fuperiority was indeed acknowledged in the laft war.

It had been alledged, that by frequent diftillation water is converted into earth. This queftion Lavoifier refolved in 1778, having fhewn that the earthy fediment was owing to the continual erofion of the internal furface of the retort. In that fame year he made a more interefting difcovery; namely, that the refpirable portion of the atmofphere is a conftituent principle of all acids, and which he therefore denominated *oxygen:* a moft important fact, and the firft great ftep towards the new chemiftry; which the compofition of water, afcertained in 1783, triumphantly completed.

Lavoifier poffeffed decifive advantages over his contemporaries; he ftudied a geometrical accuracy of inveftigation; and his wealth enabled him to make experiments on a large fcale, and to ufe inftruments of the moft perfect conftruction. He was able to hold in his houfe, twice every week, affemblies, to which he invited every literary character that was moft celebrated in geometrical, phyfical, and chemical ftudies; in thefe inftructive *converfationes*, difcuffions, not unlike fuch as preceded the firft eftablifhment of academies, regularly took place. Here the opinions of the moft eminent literati in Europe were canvaffed; paffages the moft ftriking and novel, out of foreign writers, were recited and animadverted on; and theories were compared with experiments. Here learned men of all nations found eafy admiffion; Prieftley, Fontana, Blagden, Ingenhoufz, Landriani, Jacquin, Watt, Bolton, and other illuftrious phyfiologifts and chemifts of England, Germany, and Italy, found themfelves mixed in the fame company with La Place, La Grange, Borda, Coufin, Meunier, Vandermonde, Monge, Morveau, and Berthollet. Happy hours paffed in thefe learned interviews, wherein no fubject was left uninveftigated that could poffibly contribute to the progrefs of the fciences, and the amelioration and happinefs of man. One of the greateft benefits refulting from thefe affemblages, and the influence of which was foon afterwards felt in the academy itfelf, and confequently in all the phyfical and chemical works that have been publifhed for the laft twenty years in France, was the agreement eftablifhed in the methods of reafoning between the natural philofophers and the geometricians. The precifion, the feverity of ftyle, the philofophical method of the latter, was infenfibly transfufed into the minds of the former; the philofophers became difciplined in the tactics of the geometricians, and were gradually moulded into their refemblance.

It was in the affemblage of thefe talents that Lavoifier embellifhed and improved his own. When any new refult from fome important experiment prefented itfelf, a refult which threatened to influence the whole theory of the fcience, or which contradicted theories till then adopted, he repeated it before this felect fociety. Many times fucceffively he invited the fevereft objections of his critical friends; and it was not till after he had furmounted their objections, to the conviction and entire perfuafion of the fociety; it was not till after he had removed from it all myftery and obfcurity, that he ventured to announce to the world any difcovery of his own.

At length he combined his philofophical views into a confiftent body, which he publifhed in 1789, under the title of *Elements of Chemiftry;* a book which is a moft beautiful model of fcientific compofition, clear, logical, and elegant. It would be foreign to our purpofe to attempt an expofition of the principles, or to expatiate

tiate on the merits, of this celebrated syftem; which, within the fpace of a very few years, has been almoft univerfally adopted, and which, if not the genuine interpretation of nature, approaches as near to it as the prefent ftate of knowledge will permit. See CHEMISTRY in this *Supplement*.

The laft, but not the leaft ufeful, of Lavoifier's philofophical refearches, on the Perfpiration of Animals, was read to the Academy on the 4th May 1791, and of which part was publifhed in the volume for 1790. He found, by fome delicate experiments, made in conjunction with Seguin, that a man in 24 hours perfpires 45 ounces; that he confumes 33 ounces of vital air; that he difcharges from the lungs 8 cubic feet of carbonic acid gas, of which one-third is carbon and two-thirds are oxygen; that the weight of water difcharged from the lungs amounts to 23 ounces, of which 3 are hydrogen and 20 oxygen, exclufive of 6 ounces of water already formed, loft in pulmonary perfpiration. Thefe difcoveries were directed to the improvement of medicine.

We have mentioned the affiftance which Lavoifier received while he was digefting his new fyftem of chemiftry; but we muft add, that to him pertains exclufively the honour of a founder. His own genius was his fole conductor, and the talents of his affociates were chiefly ufeful in illuftrating difcoveries he himfelf had made; he firft traced the plan of the revolution he had been a long time conceiving; and his colleagues had only to purfue and execute his ideas.

In the twenty volumes of the Academy of Sciences, from 1772 to 1793, are 40 memoirs of Lavoifier, replete with all the grand phenomena of the fcience; the doctrine of combuftion, general and particular; the nature and analyfis of atmofpherical air; the formation and fixation of elaftic fluids; the properties of the matter of heat; the compofition of acids; the augmentation of the ponderofity of burnt bodies; the decompofition and recompofition of water; the diffolution of metals; vegetation, fermentation, and animalization. For more than 15 years confecutive, Lavoifier purfued, with unfhaken conftancy, the route he had marked out for himfelf, without making a fingle falfe ftep, or fuffering his ardour to be damped by the numerous and increafing obftacles which conftantly befet him.

Many were the fervices rendered by Lavoifier, in a public and private capacity, to manufactures, to the fciences, and to artifts. He was treafurer to the Academy after Buffon and Tillet, and introduced economy and order into the accounts. He was alfo a member of the Board of Confultation, and took an active fhare in whatever was going forwards. When the new fyftem of meafures was agitated, and it was propofed to determine a degree of the meridian, he made accurate experiments on the expanfion of metals, and conftructed a metalline thermometer. By the National Convention he was confulted on the means of improving the manufacture of affignats, and of increafing the difficulties of forging them.

Like a good citizen, Lavoifier turned his thoughts to political economy. Between the years 1778 and 1785, he allotted 240 *arpents* in the Vendômois to experimental agriculture, and increafed the ufual produce by one-half. In 1791, he was invited by the Conftituent Affembly to digeft a plan for fimplifying the collection of the taxes. This gave occafion to an excellent report, afterwards printed with the title of *Territorial Riches of France*. At this time, alfo, he was appointed commiffionary of the national treafury, in which he effected fome beneficial reforms.

During the horrors of the Robefpierrean dictatorfhip, Lavoifier told La Lande that he forefaw he fhould be ftripped of his property, but that he would work for his bread. The profeffion of apothecary would have fuited him the beft. But his doom was already fixed. On the 8th of May 1794, confounded with 28 farmers-general, he fuffered on the fcaffold, merely becaufe he was rich!

Lavoifier was tall, and of a graceful fprightly appearance. He was mild, fociable, obliging, and extremely active; and in his manners he was unaffectedly plain and fimple. Many young men, not bleffed with the gifts of fortune, but incited by their genius to woo the fciences, have confeffed their obligations to him for pecuniary aid; many, alfo, were the unfortunate whom he relieved in filence, and without the oftentation of virtue. In the communes of the department of the *Loir* and *Char*, where he poffeffed confiderable eftates, he would frequently vifit the cottages of indigence and diftrefs; and long will his memory be cherifhed there. But his reputation, influence, virtues, and wealth, gave him a great preponderance, which unfortunately prevoked the jealoufy of a crew of homicides, who made a fport of facrificing the lives of the beft of men to a fanguinary idol.

This great and good man married, in 1771, Marie-Anni-Pierette Paulze, daughter of a farmer-general; a woman whofe wit and accomplifhments conftituted the charm of his life; who affifted him in his labours, and even engraved the figures of his laft work.

LEAD. See that article, *Encycl*, and CHEMISTRY-*Index* in this *Supplement*. It is well known that lead generally contains a portion of filver, and fometimes of gold; and that there are occafions, particularly in affaying, when it is of importance to have it freed from thefe metals. For accomplifhing thefe purpofes different proceffes have been propofed; but the following, by Pet. Jac. Hjelm, as it is the leaft expenfive, promifes to be the moft ufeful:

LITHARGE (fee *Encycl.*) was the fubftance on which this chemift made his experiments, and his principal object was to free it from all mixture of filver. This was accomplifhed in the following manner: He placed a crucible, in which half a pound of litharge found good room, and which was fitted with a clofe cover, in a wind furnace filled with dead coals. He then put into the crucible a mixture of four ounces of potafh and the fame quantity of powder of flint. When the whole was well melted by ftrengthening the draught, and making the coals glow, he took off the cover, and laid hold of the crucible with a pair of tongs, in order to take it out, and to fuffer this very fufible glafs to cover the infide of the crucible, to fecure it from the glafs of the lead which he meant to melt in it. The fuperfluous glafs was poured out; the crucible again placed on its foot, and half a pound of litharge thrown into it with a fhovel. The cover was placed upon it while the litharge was melting; and when it was thoroughly glowing

Lead, Ledyard.

glowing with fluid, charcoal dust was sifted into the uncovered crucible through a sieve, so that the surface of the litharge was completely covered with it. This immediately produced an effervescence, and the rising of bubbles, by means of the separation of the air occasioned by the reduction of the lead. During this process, the cover was put on, and a few coals thrown into the furnace: when these were burnt, every thing in the crucible was quiet, and the melted mass was poured into a warm conical mould. The crucible was then again filled with half a pound of the same kind of litharge, and put into the furnace, and charcoal dust was several times sifted over the melted surface, till it was well covered before the mass was thrown out, a sufficient space being every time left for the effervescence. The first mass had, in the mean time, become cool, and, on examination, contained four ounces of lead at the bottom, and litharge at the top. When this litharge was reduced with potashes and wine stone, the lead thence obtained, which weighed 23 ounces, was found to contain less than one-half grain of silver in the pound. In the second mass there was found somewhat more than six ounces of lead, which contained all the silver that had been before mixed with the litharge, because in the lead which had been reduced from the litharge in the above manner, there were no perceptible traces of silver. This lead was then melted over a slow fire, and cast into bars, which were rolled smooth, and formed into masses of a known weight, to be used for assaying gold and silver, and for other purposes of the same kind. All these meltings were made in one crucible, which, according to every appearance, remained unhurt. If the same experiments were made with red lead, the like result would infallibly follow.

With the same view of obtaining lead free from silver, he melted, in the like manner, half a pound of white lead, which produced half an ounce of lead. When the litharge standing over it was revived, the lead obtained was still found to contain too much silver. He therefore precipitated another half pound of white lead by charcoal powder, after the lead that fell from it had been separated; and then it produced, by reviving, a mass of lead without any mixture of silver.

LEDYARD (———), the celebrated, though unfortunate, traveller, was a native of North America, but of what province we have not learned. We are equally ignorant of the year of his birth, and the rank of his parents; but have no reason to think that they were opulent. From his early youth he displayed a strong propensity to visit unknown and savage countries; and to gratify that propensity, he lived for several years with the American Indians, whose manners and habits he seemed in some degree to have acquired. Afterwards he sailed round the world with Captain Cook in the humble station of a corporal of marines; and on his return, he determined to traverse the vast continent of America, from the Pacific to the Atlantic Ocean.

This design being frustrated by his not obtaining a passage to Nootka Sound, he determined to travel over land to Kamschatka. With this view he went over to Ostend, with only ten guineas in his pocket, and proceeded by the way of Denmark and the Sound to the capital of Sweden, and endeavoured to cross the Gulph of Bothnia on the ice; but finding, when he came to the middle, that the water was not frozen, he walked round the gulph to Petersburgh. Here he found himself without stockings or shoes; but procured relief from the Portuguese ambassador, and obtained leave to proceed with a detachment of stores to Yakutz. He made this journey of six thousand miles, and there met Mr Billengs, an Englishman, whom he had known on board Captain Cook's ship. From thence he went to Oczakow, on the coast of the Kamschatka Sea; but being too late to embark that year, returned to Yakutz to winter. Here he was, on some suspicion, seized, conveyed on a sledge through Northern Tartary, and left on the frontiers of the Polish dominions. In the midst of poverty, rags, and disease, he however reached Koningsburgh, where he found friends that enabled him to reach England.

Ledyard.

On his arrival in London, he waited on Sir Joseph Banks, on whose credit he had, in his distress, received at different times 25 guineas. Sir Joseph communicated to him the views of the African Association, and pointed out the route in which they wished Africa to be explored. On his engaging at once in the enterprise, Sir Joseph asked him when he would be able to set out. "To-morrow morning," replied Ledyard, without hesitation. At this interview the president of the Royal Society declares, that he was struck with the figure of the man, the breadth of his chest, the openness of his countenance, and the rolling of his eye. Though scarcely exceeding the middle size, his figure indicated great strength and activity. Despising the accidental distinctions of society, he seemed to regard no man as his superior; but his manners, though coarse, were not disagreeable. His uncultivated genius was original and comprehensive. From the native energy of his mind, he was adventurous, curious, and unappalled by dangers; while the strength of his judgment united caution with energy. The track pointed out to him was from Cairo to Senaar, and thence westward in the latitude and supposed direction of the Niger.

He was not ignorant that the task assigned him was arduous and big with danger; but instead of shrinking from it, he said, on the day of his departure, "I am accustomed to hardships; I have known both hunger and nakedness to the utmost extremity of human suffering; I have known what it is to have food given me as charity to a madman; and I have at times been obliged to shelter myself under the miseries of that character to avoid a heavier calamity. My distresses have been greater than I ever owned, or ever will own to any man. Such evils are terrible to bear, but they never yet had power to turn me from my purpose. If I live, I will faithfully perform, in its utmost extent, my engagement to the Society: and if I perish in the attempt, my honour will be safe; for death cancels all bonds."

After receiving his instructions and letters of recommendation, this intrepid traveller sailed from London on the 30th of June 1788; and in 36 days arrived at Alexandria. Proceeding to Cairo, where he arrived August the 17th, he visited the slave markets, and conversed with the travelling merchants of the caravans. These sources of information, generally neglected by travellers, enabled him to obtain, at a very small expence, more correct information concerning the African nations and their trade, the position of places, the nature of the country, the manner of travelling, &c. than could have been easily obtained by any other method. He thus

Ledyard. thus learned, that the Arabs of the desert have an invincible attachment to liberty, though it is singular that they have no word to express liberty in their language. The Mahomedans of Africa are a trading, superstitious, and warlike set of vagabonds. He saw near 200 black slaves exposed to sale, who had been brought from the interior parts of Africa; their appearance savage, but not like prisoners of war; they had head ornaments, and their hair plaited in detached plaits of great length. Another parcel, which had come from Darfoor, were mostly women; and the beads, and some other ornaments which they wore, were Venetian. They were well formed, quite black, had the true Guinea face, and curled hair. Mr Ledyard was informed, that the king of Senaar was a merchant, and concerned in the caravans; that 20,000 negro slaves are imported into Egypt annually. Among some Senaar slaves, he saw three of a bright olive colour, but their heads uncommonly formed, the forehead the narrowest, longest, and most protuberant he ever saw.

The Senaar caravan is the most rich; that of Darfoor is not equally so, though it trades with almost the same commodities. Besides slaves, these are gum, elephants teeth, camels, and ostrich-feathers; for which are received in exchange trinkets, soap, antimony, red linen, razors, sciffars, mirrors, and beads. Wangara, to which the caravans also trade, was represented to Mr Ledyard as a kingdom producing much gold; but the king seems to intermiddle with commerce as well as the potentate of Senaar; for in order to deceive strangers. and prevent them from guessing at the extent of his riches, he was reported to vary continually the gold used in barter, which it is his province to regulate, and of which he issues at one time a great quantity, and at others little or none. A caravan goes from Cairo to Fezzan, which they call a journey of fifty days; and as the caravans travel about 20 miles a day, the distance must be about 1000 miles; from Fezzan to Tombuctoo is 1800 miles; from Cairo to Senaar about 600 miles.

Such was the information which Mr Ledyard derived from the merchants of the caravans in Egypt; but when he was about to verify it by his own observations, and had announced to the Association that his next dispatch would be dated from Senaar, he was seized with a bilious complaint, which frustrated the skill of the most eminent physicians, and put a period to his travels and his life at Cairo. It is needless to say how much his death was regretted, or how well he was qualified for the arduous enterprise in which he had engaged. The person who, with such scanty funds, could penetrate the frozen regions of Tartary, subsist among their churlish inhabitants, and ingratiate himself with the ferocious Moors of Egypt, could hardly have failed to obtain a kind reception from the gentle and hospitable Negro, had no untoward circumstance intervened. At Senaar, indeed, his risk would have been great; and Mr Bruce was decidedly of opinion, that a man so poorly attended as Mr Ledyard, could never have made his escape from that treacherous and ferocious people.

The observations of this accurate observer on the female character, though they have been repeatedly quoted in other works, are well entitled to a place here; and with them we shall conclude this sketch of his life: "I have always (says he) remarked, that women in all countries are civil and obliging, tender and humane; that they are ever enclined to be gay and cheerful, timorous and modest; and that they do not hesitate, like man, to perform a generous action. Not haughty, not arrogant, not supercilious; they are full of courtesy, and fond of society; more liable, in general, to err than man; but in general also more virtuous, and performing more good actions than he. To a woman, whether civilized or savage, I never addressed myself, in the language of decency and friendship, without receiving a decent and friendly answer. With man it has often been otherwise. In wandering over the barren plains of inhospitable Denmark, through honest Sweden, and frozen Lapland, rude and churlish Finland, unprincipled Russia, and the wide spread regions of the wandering Tartar; if hungry, dry, cold, wet, or sick, the women have ever been friendly to me, and uniformly so. And to add to this virtue (so worthy the appellation of benevolence), these actions have been performed in so free and kind a manner, that if I was dry, I drank the sweetest draught; and if hungry, I eat the coarsest morsel with a double relish." For a fuller account of *Ledyard*, see *The Transactions of the African Association*, or *A View of the Late Discoveries in Africa*

Ledyard ‖ Lemyngton

Hyperbolic LEGS, are the ends of a curve line that partakes of the nature of the hyperbola, or having asymptots.

LEMINGTON Priors, is a village two miles east of the town of Warwick, famous for its mineral waters. One salt spring, which rises near the church yard, has been long known, as well as another which rises in the bed of the river; but the most remarkable spring was discovered in the year 1790. The waters of both springs have been analyzed with great accuracy by William Lambe, M. A. late Fellow of St John's colledge, Cambridge, who has given us the following synoptical table of the substances contained in them:

Gaseous Fluids contained in a Wine-gallon in Cubic inches.

	Water of the new spring.	Water of the old spring.
Hepatic gas -	*Too small to be measured.*	*Too small to be measured.*
Azotic gas -	3.5	3
Carbonic acid gas	.5	—

Solid contents of a Wine-gallon in Grains.

	Water of the new spring.	Water of the old spring.
Carbonat of iron	.75	
Oxyds of iron and manganese -	—	*Too small to be weighed.*
Oxygenated muriat of iron and manganese - -	*Unknown, but very small.*	*Unknown, but very small.*
Sulphur - -	*Unknown, but very small.*	——
Muriat of magnesia	11.5	58
Muriat of soda	430	350
Sulphat of Soda	152	62
Sulphat of lime	112	146

In the course of his experiments, for which we must refer to the original memoir, in Transactions of the Manchester Society, Mr Lambe thinks he discovered the origin of the *muriatic acid*. He found a coincidence, very unexpected, between the hepatised solution of iron and the oxygenated muriat of iron. "I had almost concluded (says he), from the resemblance between the properties of this salt and the phenomena of the water, that the water contains this very salt. Now, I conclude, that they contain a matter, be it what it may, produced by the action of hepatic gas on iron. But they are the very same facts which form the basis, upon which each separate inference is built. Does it not follow, then, as a necessary consequence, that the hepatised solution itself contains a muriat of iron highly oxygenated, and that therefore *in this process muriatic acid is generated?* This conclusion seemed authorised by reason, and experiment has confirmed it."

LEMNISCATE, the name of a curve in the form of the figure of 8.

LEMON Juice, is an article of such harmless luxury, and in some cases of such real utility, that many of our readers will be pleased to know a simple method by which they may obtain it in great purity. In the article Chemistry (*Suppl.*), n° 476, we have shewn from Scheele and Dizé, how to obtain the citric acid perfectly pure, and in the form of crystals; but here we mean nothing more than to shew how it may be completely separated from that slimy substance with which it is always mixed in the lemon, without allowing it time to spoil or to acquire any disagreeable taste during the separation. This we are enabled to do by M. Brugnatelli, who, in the second volume of the *Annali de Chimia*, informs us, that he expressed in the common manner the juice of perfectly ripe lemons, and strained it through a piece of linen. In half an hour he strained it again, to free it from a little slimy matter which had settled at the bottom of the vessel. He then added to the juice a certain quantity of the strongest spirit of wine, and preserved the mixture for some days in a well-corked bottle. During that time there was a considerable deposit, which to all appearance was of a slimy nature, and which he separated by filtering paper. If the fluid was too thick to pass through the filter, he diluted it again with spirit of wine. After this operation, the deposit remained on the paper, which was entirely covered with it; and he obtained, in the vessel placed below, the purest acid of lemons combined with spirit of wine.

If it be required to obtain the acid perfectly pure, nothing is necessary but to separate from it the spirit of wine, which can be best effected by evaporation. The acid of the lemons assumes, after it has been freed from the spirit of wine and the moisture combined with it, a yellowish colour, and becomes so strong, that by its taste it may be considered as a mineral acid.

It is not necessary to evaporate the spirit of wine in a close vessel, if the experiment is made only on a small scale; nor is there any danger that in open vessels any of the acid will be lost, as it is too fixed to be votalitised by the same degree of heat at which spirit of wine evaporates. This acid has peculiar properties, which deserve farther examination.

LENSES (see Lens and Dioptrics, *Encycl.*), are either blown or ground.

Blown Lenses are used only in the single microscope; and the usual method of making them has been to draw out a fine thread of the soft white glass called *crystal*, and to convert the extremity of this into a spherule by melting it at the flame of a candle. But this glass contains lead, which is disposed to become opake by partial reduction, unless the management be very carefully attended to. We are informed, however, by Mr Nicholson, that the hard glass used for windows seldom fails to afford excellent spherules. This glass is of a clear bright green colour when seen edgewise. A thin piece was cut from the edge of a pane of glass less than one-tenth of an inch broad. This was held perpendicularly by the upper end, and the flame of a candle was directed upon it by the blow-pipe at the distance of about an inch from the lower end. The glass became soft, and the lower piece descended by its own weight to the distance of about two feet, where it remained suspended by a thin thread of glass about one five-hundreth of an inch in diameter. A part of this thread was applied endwise to the lower blue part of the flame of the candle without the use of the blow-pipe. The extremity immediately became white-hot, and formed a globule. The glass was then gradually and regularly thrust towards the flame, but never into it, until the globule was sufficiently large. A number of these were made; and being afterwards examined, by viewing their focal images with a deep magnifier, proved very bright, perfect, and round. This, as the ingenious author observes, may prove an acceptable piece of information to those eminent men (and there are many such), whose narrow circumstances, or remote situations, are obliged to have recourse to their own skill and ingenuity for experimental implements.

Ground Lenses, are such as are ground or rubbed into the desired shape, and then polished. Different shapes have been proposed for lenses; but in the article Optics, n° 251 (*Encycl.*), it has been shewn that, after all, the spherical is the most practically useful. By many of the methods of grinding, however, the artificer, with his utmost care, can only produce an approximation to a truly spherical figure; and, indeed, gentlemen have, for the most part, nothing to depend on for the sphericity of the lenses of their telescopes, but the care and integrity of the workmen. In the 41st volume of the Transactions of the Royal Society of London, a machine is described by Mr Samuel Jenkins, which, as it is contrived to turn a sphere at one and the same time on two axes, cutting each other at right angles, will produce the segment of a true sphere merely by turning round the wheels, and that without any care or skill in the workmen. The following description of this machine will enable our readers fully to comprehend its construction, and the mode of using it: Plate
A is a globe covered with cement, in which are fixed XXXII.
the pieces of glass to be ground. This globe is fastened to the axis, and turns with the wheel B. C is the brass cup which polishes the glass: this is fastened to the axis, and turns with the wheel D. The motion of the cup C, therefore, is at right angles with the motion of the globe A; whence it follows demonstrably, that the pieces of glass ground by this double motion must be formed into the segments of spheres.

LEO X. is a pontiff to whom learning, and art, and science, are so deeply indebted, that not to give a sketch of his life and character, in a Work of this kind, would be an unpardonable omission. A character of him is indeed given in the *Encyclopædia*; but it is so far from the truth, Leo. truth, that it is difficult to conceive the prejudices under which he must have laboured by whom such a libel was drawn up.

Leo, whose name, before his elevation to the pontificate, was *Giovanni de Medici*, was the second son of Lorenzo de Medici, justly styled the Magnificent. In the life of that great man published in this *Supplement*, the reader will see by what means, and for what purpose, he got Giovanni raised to the dignity of cardinal at so early a period of life; and in the elegant work of Roscoe, to which we there refer, he will find such instructions of Lorenzo to the cardinal as must have made a deep impression on his youthful mind.

Speaking of his promotion, Lorenzo says, "The first thing that I would suggest to you is, that you ought to be grateful to God, and continually to recollect that it is not through your merits, your prudence, or your solicitude, that this event has taken place, but through his favour which you can repay only by a *pious*, *chaste*, and *exemplary life*; and that your obligations to the performance of these duties are so much the greater, as in your *early years* you have given some *reasonable expectation* that your riper age may produce such fruits. It would indeed be highly disgraceful, and as contrary to your duty as to my *hopes*, if at a time when others display a greater share of reason, and adopt a better mode of life, you should forget the *precepts of your youth*, and forsake the path in which you have *hitherto trodden*."—"I well know (continues Lorenzo), that as you are now to reside at Rome, that sink of all iniquity, the difficulty of conducting yourself by these admonitions will be increased. The influence of example is itself prevalent; but you will probably meet with those, who will particularly endeavour to corrupt and incite you to vice; because, as you yourself may perceive, your early attainment of so great a dignity is not observed without envy, and those who could not prevent your receiving that honour, will secretly endeavour to diminish it, by inducing you to forfeit the good estimation of the public."—"You are not unacquainted with the great importance of the character which you have to sustain; for you well know, that all the Christian world would prosper if the cardinals were what they ought to be; because in such a case there would always be a good pope, upon which the tranquillity of Christendom so materially depends."

As this was a confidential letter from Lorenzo to his son, the first of these extracts furnishes very sufficient evidence, that Giovanni had been at least a well behaved boy, diligent in his studies, and regular in his conduct; and without supposing him remarkably religious, the admonitions of such a father, aided by his own ambition and love of letters, would surely guard him against such gross licenciousness as that of which he is accused in the *Encyclopædia*. How much he revered his father, is apparent from the letter which he wrote to his brother immediately after Lorenzo's death. "What a father (says he) have we lost! How indulgent to his children! Wonder not, then, that I grieve, that I lament, that I find no rest. Yet, my brother, I have some consolation in reflecting that I have thee, whom I shall always regard in the place of a father," Surely this is not the language of a gross sensualist, or of one who could soon forget the salutary admonitions of such a parent as Lorenzo de Medici. But it is needless to infer the decency of his character by such reasonings as these. The story published in the *Encyclopædia*, of the manner in which the Cardinal de Medici obtained the tiara, cannot possibly be true. The reader, who shall turn to the article POPE in that Work, will find that the conclave, when fitted up for an election, is so large a place, that we may safely affirm, that had the cardinal's ulcer discharged matter so fetid as to *poison all the cells*, the assertion of the physicians would have been verified, and that in the then state of the healing art, the new pope could not have survived a month. Let it be remembered, too, that Leo, at his accession, was not 30, but 37 years of age, and that he had long ruled in Florence with sovereign sway by the same means which had upheld the authority of his father. The follies of youth, therefore, had he ever been remarkable for such follies, must have been over with him; and in such a state as Florence he could not have maintained the authority of Lorenzo, without exhibiting not only Lorenzo's liberality, but likewise his decency of manners.

The next charge brought against Leo in the *Encyclopædia*, is, that he published general indulgencies throughout Europe; and this is so expressed as to lead the ill informed reader to suppose, either that no such indulgencies had ever been published by any of his predecessors, or that there was something peculiarly scandalous in Leo's mode of publishing them. Both suppositions, however, are erroneous. The historian of the council of Trent, who certainly was not partial to the court of Rome, or to the dispensing power of the pope, has shewn, that the practice of raising money, by the publication of indulgencies, had prevailed ever since the year 1100; that many former popes had raised money in this manner for purposes much less laudable than those which Leo had in his eye; and that the real cause of Luther's attack upon Leo's indulgencies was, that they were preached through Saxony by the Dominican friars; whereas the preaching of former indulgencies had been committed to the hermits of St Augustine, the order to which Luther himself belonged!

Leo is likewise accused in the *Encyclopædia* of being a professed infidel, and of having called Christianity "a fable very profitable for him and his predecessors." But of the truth of this accusation there seems not to be the shadow of evidence. Leo had too much sense to utter expressions of this kind, even had he been an unbeliever in his heart; for he could not possibly expect that his indulgencies and pardons would be purchased, had he declared in such strong terms that they were of no value. Father Paul indeed says, that he was not a deep divine, or so pious as some of his predecessors; but he affirms, that he *adorned the papacy* with many admirable qualities; that he was learned, affable, liberal, *good*; that he delighted in healing differences, and that his equal had not, for many years, filled the chair of St Peter. Surely this is not the character of a profane infidel!

Leo has been charged with raising his own family to grandeur at the expence of justice; and of dealing treacherously, in order to effect this purpose, both with the Emperor and with the French king. But the charge is either false or greatly exaggerated. He lost no opportunity indeed of aggrandizing his relations, well knowing, that in order to secure to them any lasting benefit, it was necessary that they should be powerful enough to defend themselves, after his death, from the

Leo, Leslie.

rapacious aims of succeeding pontiffs; but, in prosecuting this plan, he was so far from acting tyrannically or injuriously to others, that during his pontificate, the papal dominions enjoyed a degree of tranquillity superior to any other Italian state. During the contests that took place between the emperor and the French king, so far from acting treacherously, he distinguished himself by his moderation, his vigilance, and his political address; on which account he is justly celebrated by an eminent historian of our own*, as "the only prince of the age who observed the motions of the two contending monarchs with a prudent attention, or who discovered a proper solicitude for the public safety."

* Dr Robertson.

We trust that no zealous Protestant will think we have employed our time ill, in vindicating the character of this splendid pontiff; for good learning, and, of course, true religion, are more indebted to Leo X. than to any other individual of the age in which he lived, his father Lorenzo alone excepted.

Leo Minor, the *Little Lion*, a constellation of the northern hemisphere, and one of the new ones that were formed out of what were left by the ancients, under the name of *Stellæ Informes*, or unformed stars. See ASTRONOMY, n° 406. *Encycl.*

LESLIE (Charles), was a man so eminent for his learning, his talents, and his piety, that a fuller account of him than that which is given in the *Encyclopædia* must be acceptable to our Christian readers. He was the second son of Dr John Leslie bishop of Clogher in Ireland, who was descended from an ancient family in the north of Scotland, and being an admirable scholar, rose to the dignity of bishop of Orkney in his own country, whence he was translated, in 1633, to Raphoe in Ireland, and afterwards, in 1661, to the see of Clogher.

Our author was born in Ireland, but in what year we have not learned. A ludicrous story goes indeed of his having been begotten in prison, and of his father having said that he hoped he would in consequence become the greatest scourge of the covenanters that Great Britain or Ireland had ever seen. This story, with all its circumstances as told to us, can hardly be true; but we think it could not have been fabricated, had not Charles Leslie been born within a year of Cromwell's conquest of Ireland, when the good bishop, having sustained a siege in his castle of Raphoe against that arch rebel, was some time kept in close confinement.

We are equally ignorant of the school where he was educated as of the year of his birth; but we know that he had his academical education in Trinity College, Dublin, where he took the degree of master of arts. In the year 1671, he lost his father, when he came over to England, and, entering himself in the Temple, studied law for some years, but afterwards relinquished it for the study of divinity. In 1680, he was admitted into holy orders; and, in 1687, was made chancellor of Connor.

About this period he rendered himself particularly obnoxious to the Popish party in Ireland, by his zealous opposition to them, which was thus called forth. Roger Boyle, bishop of Clogher, dying in 1687, Patrick Tyrrel was made titular Popish bishop, and had the revenues of the see assigned him by king James. He set up a convent of friars in Monaghan: and, fixing his habitation there, held a public visitation of his clergy with great solemnity; when, some subtile logicians attending him, he was so insolent as to challenge the Protestant clergy to a public disputation. Leslie undertook the task, and performed it to the satisfaction of the Protestants; though it happened, as it generally does at such contests, that both sides claimed the victory. He afterwards held another public disputation with two celebrated Popish divines, in the church of Tynan, in the diocese of Armagh, before a very numerous assembly of persons of both religions; the issue of which was, that Mr John Stewart, a Popish gentleman, solemnly renounced the errors of the church of Rome.

Biographical Dictionary.

As the Papists had got possession of an Episcopal see, they engrossed other offices too; and a Popish high-sheriff was appointed for the county of Monaghan. This proceeding alarmed the gentlemen in that county; who, depending much on Leslie's knowledge as a justice of peace, repaired to him, then confined by the gout to his house. He told them, that it would be as illegal in them to permit the sheriff to act as it would be in him to attempt it. But they insisting that he should appear himself on the bench at the next quarter sessions, and all promising to stand by him, he was carried thither with much difficulty and in great pain. When the sheriff appeared, and was taking his place, he was asked whether he was legally qualified; to which he answered pertly, "That he was of the king's own religion, and it was his Majesty's will that he should be sheriff." Leslie replied, "That they were not inquiring into his Majesty's religion, but whether he (the pretended sheriff) had qualified himself according to law, for acting as a proper officer; that the law was the king's will, and nothing else to be deemed such; that his subjects had no other way of knowing his will, but as it is revealed to them in his laws; and it must always be thought to continue so, till the contrary is notified to them in the same authentic manner." Upon this, the bench unanimously agreed to commit the pretended sheriff, for his intrusion and arrogant contempt of the court. Leslie also committed some officers of that tumultuous army which the Lord Tyrconnel raised for robbing the country.

In this spirited conduct Leslie acted like a sound divine and an upright magistrate; but though he thought himself authorised to resist the illegal mandates of his sovereign, like many other great and good men, he distinguished between active and passive obedience, and felt not himself at liberty to transfer his allegiance from that sovereign to another. Refusing therefore to take the oaths to king William and queen Mary, he was deprived of all his preferments; and in 1689 he removed with his family to England, where he published the following works, besides those already noticed in the *Encyclopædia*: 1, Answer to Archbishop King's State of the Protestants in Ireland. 2. Cassandra, concerning the new Associations, &c. 1703, 4to. 3. Rehearsals; at first a weekly paper, published afterwards twice a-week in a half-sheet, by way of dialogue on the affairs of the times; begun in 1704, and continued for six or seven years. 4. The Wolf stripped of his Shepherd's Clothing, in Answer to Moderation a Virtue, 1704, 4to. The pamphlet it answers was written by James Owen. 5. The Bishop of Sarum's [Burnet's] proper Defence, from a speech said to be spoken by him against occasional conformity, 1704, 4to. 6. The new Association

Aſſociation of thoſe called Moderate Churchmen, &c. occaſioned by a pamphlet, entitled, The Danger of Prieſtcraft, 1705, 4to. 7. The new Aſſociation, part 2d, 1705, 4to. 8. The Principles of Diſſenters concerning Toleration and occaſional Conformity, 1705, 4to. 9. A warning for the Church of England, 1706, 4to. Some have doubted whether theſe two pieces were his. 10. The good old Cauſe, or Lying in Truth; being a ſecond Defence of the Biſhop of Sarum from a ſecond Speech, &c. 1710. For this a warrant was iſſued out againſt Leſlie. 11. A Letter to the Biſhop of Sarum, in Anſwer to his Sermon after the Queen's Death, in Defence of the Revolution, 1715. 12. Salt for the Leech. 13. The Anatomy of a Jacobite. 14. Gallienus redivivus. 15. Delenda Carthago. 16. A Letter to Mr William Molyneux, on his Caſe of Ireland's being bound by the Engliſh Acts of Parliament. 17. A Letter to Julian Johnſon. 18. Several Tracts againſt Dr Higden and Mr Hoadly. 19. A Diſcourſe, ſhewing who they are that are now qualified to adminiſter Baptiſm. 20. The Hiſtory of Sin and Hereſy, &c. 1698, 8vo. 21. The Truth of Chriſtianity demonſtrated, in a Dialogue between a Chriſtian and a Deiſt, 1711, 8vo.—Againſt the Papiſts: 22. Of private Judgment and Authority in Matters of Faith. 23. The Caſe ſtated between the Church of Rome and the Church of England, &c. 1713. 24. The true notion of the Catholic Church, in Anſwer to the Biſhop of Meaux's Letter to Mr Nelſon, &c.

Beſides theſe, he publiſhed the four following Tracts: 25. A Sermon preached in Cheſter, againſt Marriages in different Communions, 1702, 8vo. This ſermon occaſioned Mr Dodwell's diſcourſe upon the ſame ſubject. 26. A Diſſertation concerning the Uſe and Authority of Eccleſiaſtical Hiſtory. 27. The Caſe of the Regal and the Pontificate. 28. A Supplement, in Anſwer to a Book, entitled, The regal Supremacy in Eccleſiaſtical Affairs aſſerted, &c. Theſe two laſt pieces were occaſioned by the diſpute about the rights of convocation, between Wake, &c. on one ſide, and Atterbury and his friends, among whom was Leſlie, on the other.

It is ſaid by the authors of the Biographical Dictionary, that, in conſequence of a publication of his, entitled, "The hereditary right of the crown of England aſſerted," he was under the neceſſity of leaving the kingdom; and that he repaired to the Pretender at *Bar le duc*, where he was allowed to officiate, in a private chapel, after the rites of the church of England; and where he endeavoured, though in vain, to convert the Pretender to the Proteſtant religion.

That he repaired to *Bar le duc*, and endeavoured to convert to the church of England him whom he conſidered as the rightful ſovereign of England, is indeed true; but we have reaſon to believe that this was not in conſequence of his being obliged to leave the kingdom. There is, in the firſt place, ſome grounds to believe, that "The hereditary right of the crown of England aſſerted" was not written by him; and there is ſtill in exiſtence undoubted evidence, that, in conſequence of his great fame as a polemic, he was ſent to *Bar le duc* for the expreſs purpoſe of endeavouring to convert the ſon of James II. by ſome gentlemen of fortune in England, who wiſhed to ſee that prince on the throne of his anceſtors. The writer of this article had the honour, 16 or 17 years ago, to be known to the granddaughter of one of thoſe gentlemen—a lady of the ſtricteſt veracity; and from her he received many anecdotes of Leſlie and his aſſociates, which, as he did not then foreſee that he ſhould have the preſent occaſion for them, he has ſuffered to ſlip from his memory. That lady is ſtill alive, and we have reaſon to believe is in poſſeſſion of many letters by Leſlie, written in confidence to her grandfather, both from *Bar le duc* and from St Germains; and by the account which ſhe gave of theſe letters, Leſlie appears to have conſidered his prince as a weak and incorrigible bigot, though, in every thing but religion, an amiable and accompliſhed man. This may have been his genuine character; for we all know that it was the character of his father: but it is not of him that we are writing.

Mr Leſlie having remained abroad from the year 1709 till 1721, returned that year to England, reſolving, whatever the conſequences might be, to die in his own country. Some of his friends acquainting Lord Sunderland with his purpoſes, implored his protection for the good old man, which his Lordſhip readily and generouſly promiſed. Mr Leſlie had no ſooner arrived in London, than a member of the houſe of commons officiouſly waited on Lord Sunderland with the news, but met with ſuch a reception from his Lordſhip as the malice of his errand deſerved. Our author then went over to Ireland, where he died April 13. 1722, at his own houſe at Glaſlough in the county of Monaghan.

His character may be ſummed up in a few words. Conſummate learning, attended by the loweſt humility, the ſtricteſt piety without the leaſt tincture of moroſeneſs, a converſation to the laſt degree lively and ſpirited, yet to the laſt degree innocent, made him the delight of mankind, and leaves what Dr Hickes ſays of him unqueſtionable, that he made more converts to a ſound faith and holy life than any other man of our times.

A charge, however, has been lately brought againſt him of ſuch a nature, as, if well founded, muſt detract not only from his literary fame, but alſo from his integrity. "The ſhort and eaſy method with the Deiſts" is unqueſtionably his moſt valuable, and apparently his moſt original work; yet this tract is publiſhed in French among the works of the Abbé St Real, who died in 1692; and therefore it has been ſaid, that unleſs it was publiſhed in Engliſh prior to that period, Charles Leſlie muſt be conſidered as a ſhameleſs plagiary.

The Engliſh work was certainly not publiſhed prior to the death of Abbé St Real; for the firſt edition bears date July 17th 1697; and yet many reaſons conſpire to convince us, that our countryman was no plagiary. There is indeed a ſtriking ſimilarity between the Engliſh and the French works; but this is no complete proof that the one was copied from the other. The article Philology in the *Encyclopædia Britannica*, of which Dr Doig is the author, was publiſhed the very ſame week with Dr Vincent's diſſertation on the Greek verb. It was therefore impoſſible that either of theſe learned men, who were till then ſtrangers to each others names, could have ſtolen aught from the other; and yet Dr Vincent's derivation of the Greek verb bears as ſtriking a reſemblance to Dr Doig's as the Abbé St Real's work does to Charles Leſlie's. In the article Miracle (*Encycl.*), the credibility of the goſpel miracles is eſtabliſhed by an argument, which the author certainly borrowed from no man, and which the late Principal

Campbell

Campbell considered as original; yet within half-a-year of the publication of that article, the credibility of the gospel-miracles was treated in the very same manner by F. Sayers, M. D. though there is in his dissertation complete internal evidence that he had not seen the article in the *Encyclopædia*. Not many months ago, the author of this sketch reviewed, in one of the journals, the work of a friend, which was at the same time reviewed in another journal, that at this moment he has never seen. Yet he has been told by a friend, who is much versant in that kind of reading, and knows nothing of his concern with either review, that the book in question must, in both journals, have been reviewed by the same hand; because in both the same character is given of it in almost the very same words!

After these instances of apparent plagiarism, which we know to be *only* apparent, has any man a right to say that Charles Leslie and the Abbé St Real might not have treated their subject in the way that they have done, without either borrowing from the other? The coincidence of arrangement and reasoning in the two works is indeed very surprising; but it is by no means so surprising as the coincidence of etymological deductions which appears in the works of the Doctors Doig and Vincent. The divines reason from the acknowledged laws of human thought; the reasonings of the grammarians, with all due deference to their superior learning, we cannot help considering as sometimes fanciful.

But this is not all that we have to urge on the subject. If there be plagiarism in the case, and the identity of titles looks very like it, it is infinitely more probable that the editor of St Real's works stole from Leslie, than that Leslie stole from St Real, unless it can be proved that the works of the Abbé, and this work in particular, were published before the year 1697. At that period, the English language was very little read or understood on the continent; whilst in Britain the French language was, by *scholars*, as generally understood as at present. Hence it is, that so many Frenchmen, and indeed foreigners of different nations, thought themselves safe in pilfering science from the British philosophers*; whilst there is not, that we know, one well authenticated instance of a British philosopher appropriating to himself the discoveries of a foreigner. If, then, such men as LEIBNITZ, John BERNOULLI, and Des CARTES, trusting to the improbability of detection, condescended to pilfer the discoveries of HOOKE, NEWTON, and HARRIOT, is it improbable that the editor of the works of St Real would claim to his friend a celebrated tract, of which he knew the real author to be obnoxious to the government of his own country, and therefore not likely to have powerful friends to maintain his right?

* See *Quantity* (Encycl.), *Astronomy*, *Dynamics*, *Impulsion*, and *Harriot*, in this Suppl.

But farther, Burnet, bishop of Sarum, was an excellent scholar, and well read, as every one knows, in the works of foreign divines. Is it conceivable, that this prelate, when smarting under the lash of Leslie, would have let slip so good an opportunity of covering with disgrace his most formidable antagonist, had he known that antagonist to be guilty of plagiarism from the writings of the Abbé St Real? Let it be granted, however, that Burnet was a stranger to these writings and to this plagiarism; it can hardly be supposed that *Le Clarc* was a stranger to them likewise. Yet this author, when, for reasons best known to himself, he chose (1706) to depreciate the argument of *the short method*, and to traduce its author as ignorant of ancient history, and as having brought forward his four marks for no other purpose than to put the deceitful traditions of Popery on the same footing with the most authentic doctrines of the gospel, does not so much as insinuate that he borrowed these marks from a Popish abbé, though such a charge, could he have established it, would have served his purpose more than all his rude railings and invective. But there was no room for such a charge. In the second volume of the works of St Real, published in 1757, there is indeed a tract entitled *Methode Courte et Aisée pour combattre les Deistes*; and there can be little doubt but that the publisher wished it to be considered as the work of his countryman. Unfortunately, however, for his design, a catalogue of the Abbé's works is given in the first volume; and in that catalogue the *Methode Courte et Aisée* is not mentioned.

We have dwelt thus long on *The Short and Easy Method with the Deists*, because it is one of the ablest works that ever was written in proof of the Divine origin of the Jewish and Christian Scriptures; a work of which the merit is acknowledged by Lord Bolingbroke, and which, as has been observed elsewhere, (see THEOLOGY, n° 16. *Encycl.*) Dr Conyers Middleton confesses to be unanswerable. If by men of science we be thought to have spent our time well in vindicating the rights of our illustrious philosophers Hooke and Newton, to discoveries which have been unjustly claimed by the philosophers of Germany and France; we will not surely by the friends of Christianity be thought to have employed our time ill in vindicating Leslie's claim to this decisive argument in support of our holy religion.

LEVER, the first of the mechanical powers, for the properties of which see MECHANICS; and for a demonstration of its fundamental property, see STEEL YARD, both in the *Encyclopædia*.

LICENSER OF BOOKS (see LIBERTY *of the Press*, *Encycl.*), has been an officer in almost every civilized nation, till the end of the last century that the office was abolished in Great Britain. Professor Beckmann, with his usual industry*, has proved, that such an office was established not only in the Roman Empire, but even in the republic, and in the free states of ancient Greece. At Athens, the works of Protagoras were prohibited; and all the copies of them which could be collected were burnt by the public crier. At Rome, the writings of Numa, which had been found in his grave, were, by order of the senate, condemned to the fire, because they were contrary to the religion which he had introduced. As the populace of Rome were, in times of public calamity, more addicted to superstition than seemed proper to the government, an order was issued, that all superstitious and astrological books should be delivered into the hands of the prætor. This order was often repeated; and the emperor Augustus caused more than twenty thousand of these books to be burnt at one time. Under the same emperor the satirical works of Labienus were condemned to the fire, which was the first instance of this nature; and it is related as something singular, that, a few years after, the writings of the person who had been the cause of the order for that purpose shared the like fate, and were also

* *History of Inventions*, vol. 3d.

Cenfor, Lichen. alfo publicly burnt. When Cremutius Cordus, in his hiftory, called C. Caffius the laft of the Romans, the fenate, in order to flatter Tiberius, caufed the book to be burnt; but a number of copies were faved by being concealed. Antiochus Epiphanes caufed the books of the Jews to be burnt; and in the firft centuries of our æra the books of the Chriftians were treated with equal feverity, of which Arnobius bitterly complains. We are told by Eufebius, that Dioclefian caufed the facred Scriptures to be burnt. After the fpreading of the Chriftian religion the clergy exercifed, againft books that were either unfavourable or difagreeable to them, the fame feverity which they had cenfured in the heathens as foolifh and prejudicial to their own caufe.

Soon after the invention of printing, laws began to be made for fubjecting books to examination; a regulation propofed even by Plato; and which has been wifhed for by many fince. Our author gives a great deal of curious information on this important fubject, which our limits do not permit us to repeat; but it is apparent from his work, that the liberty of the prefs is but a modern privilege; and that it has not been enjoyed completely in any country but this happy ifland.

LICHEN (fee *Encycl.*), is a genus of Plants, of which the moft valuable fpecies feems to be the LICHEN ROCELLA, or *Argol*. As that fpecies has not been noticed in the article referred to, the following account of it from Profeffor Beckmann will be acceptable to many of our readers:

It is found in abundance in fome of the iflands near the African coaft, particularly in the Canaries, and in feveral of the iflands in the Archipelago. It grows up right, partly in fingle, partly in double ftems, which are about two inches in height. When it is old, thefe ftems are crowned with a button fometimes round, and fometimes of a flat form, which Tournefort, very properly, compares to the excrefcences on the arms of the fepia. Its colour is fometimes a light, and fometimes a dark grey. Of this mofs, with lime, urine, and alkaline falts, is formed a dark red pafte, which in commerce has the fame name, and which is much ufed in dyeing. That well-known fubftance called lacmus is alfo made of it.

Theophraftus, Diofcorides, and their tranfcriber Pliny, gave the name of *Phycos thalaffion*, or *pontion*, to this plant, which, notwithftanding its name, is not a fea weed but a mofs; as it grew on the rocks of different iflands, and particularly on thofe of Crete or Candia. It had, in their time, been long ufed for dyeing wool; and the colour it gave when frefh was fo beautiful, that it excelled the ancient purple, which was not red, as many fuppofe, but violet. Pliny tells us, that with this mofs dyers gave the ground or firft tint to thofe cloths which they intended to dye with the coftly purple. When it was firft employed as a dye by the moderns, is not fo certain, though the Profeffor has proved, we think completely, that it muft have been at leaft as early as the beinning of the 14th century.

"Among the oldeft and principal Florentine families (fays he), is that known under the name of the Oricellarii or Rucellarii, Rufcellai or Rucellai, feveral Lichen. of whom have diftinguifhed themfelves as ftatefmen and men of letters. This family are defcended from a German nobleman, named Ferro or Frederigo, who lived in the beginning of the twelfth century. One of his defcendants, in the year 1300, carried on a great trade in the Levant, by which he acquired confiderable riches, and returning at length to Florence, with his fortune, firft made known in Europe the art of dyeing with argol. It is faid, that a little before his return from the Levant, happening to make water on a rock covered with this mofs, he obferved, that the plant, which was there called *refpio*, or *refpo*, and in Spain *orciglia*, acquired by the urine a purple, or, as others fay, a red colour. He therefore tried feveral experiments; and when he had brought to perfection the art of dyeing wool with this plant, he made it known at Florence, where he alone practifed it for a confiderable time, to the great benefit of the ftate. From this ufeful invention, the family received the name of Oricellarii, from which, at laft, was formed Rucellai." The Profeffor, however, does not believe that this Florentine difcovered the dye by means of the above-mentioned accident, but that he learned the art in the Levant, and on his return taught it to his countrymen.

"Our dyers do not purchafe raw argol, but a pafte made of it, which the French call *orfeille en pâte*. The preparation of it was for a long time kept a fecret by the Florentines. The perfon who, as far as I know, made it firft known was Rofetti; who as he himfelf tells us, carried on the trade of dyer at Florence. Some information was afterwards publifhed concerning it by Imperati * and Micheli the botanift †. In later times this art has been much practifed in France, England, and Holland. Many druggifts, inftead of keeping this pafte in a moifte ftate with urine, as they ought, fuffer it to dry, in order to fave a little dirty work. It then has the appearance of a dark violet-coloured earth, with here and there fome white fpots in it.

* Lib. xxvii c. 96

† *Nova Plantarum genera Florenciæ*, 1719.

"The Dutch (continues our author), who have found out better methods than other nations of manufacturing many commodities, fo as to render them cheaper, and thereby to hurt the trade of their neighbours, are the inventors alfo of lacmus, a preparation of argol, called *orfeille en pierre*, which has greatly leffened the ufe of that *en pâte*, as it is more eafily tranfported and preferved, and fitter for ufe; and as it is befides, if not cheaper, at leaft not dearer. This art confifts, undoubtedly, in mixing with that commodity fome lefs valuable fubftance, which either improves or does not much impair its quality, and which, at the fame time, increafes its weight (A). Thus do they pound cinnabar and fmalt finer than other nations, and yet fell both thefe articles cheaper. Thus do they fift cochineal, and fell it cheaper than what is unfifted.

"It was for a long time believed, that the Dutch prepared their lacmus from thofe linen rags which in the fouth of France are dipped in the juice of the *croton tinctorium*; but at prefent, it is almoft certainly known, that *orfeille en pâte* is the principal ingredient in *orfeille en*

(A) As dry lacmus is much cheaper than moift, it may be readily fuppofed that it is adulterated with fand and other fubftances. *Valentini Hiftoria fimplicium*. Francf. ad Moen. 1716. fol. p. 152.

en pierre that is in lacmus; and for this curious information we are indebted to Ferber. But whence arises the smell of the lacmus, which appears so like that of the Florentine iris?" Some of the latter may, perhaps, be mixed with it; for our author thinks, that he has observed in it small indissoluble particles, which may have been bits of the roots. The addition of this substance can be of no use to improve the dye; but it may increase the weight, and give the lack more body; and perhaps it may be employed to render imperceptible some unpleasant smell, for which purpose the roots of that plant are used on many other occasions.

LIGHT, it has been observed in the article CHEMISTRY, n° 319. (*Suppl.*), consists of rays differently flexible. This was established by some well devised experiments made by Henry Brougham, Esq; of which it may be proper to give an account here.

In the first experiment, he darkened his chamber in the usual way, and let a beam of the sun's light into it through the hole of a metal plate fixed in the shutter of the window, $\frac{1}{30}$th of an inch in diameter. At the hole within the room he placed a prism of glass, of which the refracting angle was 45 degrees, and which was everywhere covered with black paper, except a small part on each side; and through this part the light was refracted so as to form a distinct spectrum on a chart at six feet distance from the window. In the rays, at two feet from the prism, he placed a black unpolished pin, of which the diameter was $\frac{1}{10}$ of an inch, parallel to the chart, and in a vertical position. The shadow of the pin was found in the spectrum; and this shadow had a considerable penumbra, which was broadest and most distinct in the violet part, narrowest and most confused in the red, and of an intermediate thickness and distinctness in the intermediate colours. The penumbra was bounded by curvilinear sides, convex towards the axis to which they approached as to an asymptote, so as to be nearest to it in the place of the least refrangible rays. By moving the prism on its axis, and causing the colours to ascend and descend on any bodies that were used instead of the pin; the red, wherever they fell, made the least, and the violet the greatest, shadow.

In the next experiment, a screen was substituted in the place of the pin; and this screen had a large hole, on which was a brass plate, pierced with a small hole $\frac{1}{31}$d of an inch in diameter. While an assistant moved the prism slowly on its axis, the author observed the round image made by the different rays passing through the hole to the chart; that made by the red was greatest, that of the violet least, and that of each intermediate ray was of an intermediate size. When the sharp blade of a knife was held at the back of the hole, "so as to produce the fringes mentioned by Grimaldo and Newton, these fringes in the red were broadest and most moved inwards to the shadow, and most dilated when the knife was moved over the hole; and the hole itself on the chart was more dilated during the motion when illuminated by the red than when illuminated by any other of the rays, and least of all when illuminated by the violet."

From these two experiments, the author infers "that the rays of the sun's light differ in degree of flexibility, and that those which are least *refrangible* are *most inflexible*." From other experiments he concludes, that the *most inflexible* rays are also *most deflexible*. In the sequel of his paper, he ascertains the proportion which the angle of *inflection* bears to that of *deflection* at equal incidences, and the proportion which the different *flexibilities* of the different rays bear to one another.

LIMBERS, in artillery, a sort of advanced train, joined to the carriage of a cannon on a march. It is composed of two shafts, wide enough to receive a horse between them, called the *fillet horse*: these shafts are joined by two bars of wood, and a bolt of iron at one end, and mounted on a pair of rather small wheels. Upon the axle-tree rises a strong iron spike, which is put into a hole in the hinder part of the train of the gun carriage, to draw it by. But when a gun is in action, the limbers are taken off, and run out behind it.

LIMITED Problem, denotes a problem that has but one solution, or some determinate number of solutions: as to describe a circle through three given points that do not lie in a right line, which is limited to one solution only; to divide a parallelogram into two equal parts by a line parallel to one side, which admits of two solutions, according as the line is parallel to the length or breadth of the parallelogram; or to divide a triangle in any ratio by a line parallel to one side, which is limited to three solutions, as the line may be parallel to any of the three sides.

LOCAL PROBLEM, is one that is capable of an infinite number of different solutions; because the point, which is to solve the problem, may be indifferently taken within a certain extent; as suppose any where in such a line, within such a plane figure, &c. which is called a *geometrical Locus*.

A local problem is *simple*, when the point sought is in a right line; *plane*, when the point sought is in the circumference of a circle; *solid*, when it is in the circumference of a conic section; or *sursolid*, when the point is in the perimeter of a line of a higher kind.

LOCI, the plural of

LOCUS, a line by which a local or indeterminate problem is solved; or a line of which any point may equally solve an indeterminate problem. See ALGEBRA, *Encycl.*

LOGISTIC CURVE, the same with *LOGARITHMIC Curve*, for which see *Encycl.*

LOGISTICS, or *LOGISTICAL Arithmetic*, a name sometimes employed for the arithmetic of sexagesimal fractions, used in astronomical computations.

The same term has been used for the rules of computations in algebra, and in other species of arithmetic: witness the logistics of Vieta and other writers.

Shakerly, in his *Tabulæ Britannicæ*, has a table of logarithms adapted to sexagesimal fractions, and which he calls Logistical Logarithms; and the expeditious arithmetic, obtained by means of them, he calls Logistical Arithmetic.

LIBYAN LOTUS has been described (*Encycl.*) under the title RHAMNUS; but the following additional particulars from Mr Park will be acceptable to our botanical readers:

The lotus is very common in all the countries which our author visited, and he had an opportunity to make a drawing of a branch in flower, of which an engraving is published in his travels, that with his permission we have copied (see Plate XXX.). The lotus produces fruit which the negroes call *tomberongs*. These are small farinaceous berries, of a yellow colour and delicious

cious taſte. They are much eſteemed by the natives, who convert them into a ſort of bread, by expoſing them for ſome days to the ſun, and afterwards pounding them gently in a wooden mortar, until the farinaceous part of the berry is ſeparated from the ſtone. This meal is then mixed with a little water, and formed into cakes; which, when dried in the ſun, reſemble in colour and flavour the ſweeteſt gingerbread. The ſtones are afterwards put into a veſſel of water, and ſhaken about ſo as to ſeparate the meal which may ſtill adhere to them: this communicates a ſweet and agreeable taſte to the water, and, with the addition of a little pounded millet, forms a pleaſant gruel called *fondi*, which is the common breakfaſt in many parts of Ludamar, during the months of February and March. The fruit is collected by ſpreading a cloth upon the ground, and beating the branches with a ſtick. Our author thinks there can be little doubt of this being the lotus mentioned by Pliny, as the food of the Lybian Lotophagi. An army may very well have been fed with the bread made of the meal of the fruit, as is ſaid by Pliny to have been done in Lybia; and as the taſte of the bread is ſweet and agreeable, it is not likely that the ſoldiers would complain of it.

LOWANG, a Chineſe iſland of ſome extent in the neighbourhood of the CHUSAN-Iſles, which ſee in this *Supplement*.

LOXODROMIC CURVE, or *Spiral*, is the ſame as the rhumb-line, or path of a ſhip ſailing always on the ſame courſe in an oblique direction, or making always the ſame angle with every meridian. It is a ſpecies of logarithmic ſpiral, deſcribed on the ſurface of the ſphere, having the meridians for its radii.

LOXODROMICS, the art or method of oblique ſailing, by the loxodromic or rhumb line.

LUCIOLE, a name given in the *Annales de Chimie* to the *LAMPYRIS Italica* (See LAMPYRIS, *Encycl.*). According to Dr Carradori, the light of the luciole does not depend on the influence of any external cauſe, but merely on the will of thoſe inſects. While they fly about at freedom, their ſhining is very regular; but when they are once in our power, they ſhine very irregularly, or do not ſhine at all. When they are moleſted, they emit a frequent light, which appears to be a mark of their reſentment. When placed on their backs, they ſhine almoſt without interruption, making continual efforts to turn themſelves from that poſition. In the day-time it is neceſſary to torment them in order to make them ſhine; and thence it follows, that the day to them is the ſeaſon of repoſe. The luciole emit light at pleaſure from every point of their bellies, which proves that they can move all the parts of their viſcera independently of each other. They can alſo render their phoſphoreſcence more or leſs vivid, and continue it as long as they pleaſe.

A ſlight compreſſion deprives the luciole of their power of ceaſing to ſhine. The author is inclined to believe, that the movement by which they conceal their light is executed by drawing back their phoſphoric ſubſtance into a particular membrane or tunic. He ſuppoſes alſo, that the ſparkling conſiſts in a trembling or oſcillation of the phoſphoric maſs. He is of opinion, that there is no emanation of a phoſphoric ſubſtance, and that the whole phenomenon takes place in the interior part of the luminous viſcera. When the ſhining is at its greateſt degree of height, it is ſo ſtrong that a perſon may by it eaſily diſtinguiſh the hours on the ſmalleſt watch, and the letters of any type whatever.

The phoſphoric part of the luciole does not extend farther than to the extreme rings of the belly. It is there encloſed in a covering compoſed of two portions of membranes, one of which forms the upper, and the other the lower, part of the belly, and which are joined together. Behind this receptacle is placed the phoſphorus, which reſembles a paſte, having the ſmell of garlic, and very little taſte. The phoſphoric matter iſſues from a ſort of bag on the ſlighteſt preſſure; when ſqueezed out, this matter loſes its ſplendour in a few hours, and is converted into a white dry ſubſtance. A portion of the phoſphoric belly put into oil, ſhone only with a feeble light, and was ſoon extinguiſhed. In water, a like portion ſhone with the ſame vivacity as in the air, and for a much longer time. The author thence concludes that the phoſphoreſcence of the luciole is not the effect of ſlow inflammation, nor of the fixation of azotic gas, as the oil in which they ſhine does not contain a ſingle air-bubble: beſides, the phoſphorus of theſe inſects ſhines in a barometrical vacuum. The obſervation made by Foſter, that the luciole diffuſed a more vivid light in oxygen gas than in atmoſpheric air, does not, according to Carradori, depend upon a combuſtion more animated by the inſpiration of this gas, but on the animals feeling themſelves, while in that gas, in a better condition. "Whence, then, ariſes (ſays the author) the phoſphoric light of the luciole? I am of opinion (adds he), that the light is peculiar, and innate in theſe inſects, and ſeveral other productions are peculiar to other animals. As ſome animals have the faculty of accumulating the electric fluid, and of keeping it condenſed in particular organs, to diffuſe it afterwards at pleaſure, there may be other animals endowed with the faculty of keeping in a condenſed ſtate the fluid which conſtitutes light. It is poſſible, that by a peculiar organiſation they may have the power of extracting the light which enters into the compoſition of their food, and of tranſmitting it to the reſervoir deſtined for that purpoſe, which they have in their abdomen. It is not even impoſſible that they may have the power to extract from the atmoſpheric air the luminous fluid, as other animals have the power of extracting from the ſame air, by a chemical proceſs, the fluid of heat."

Carradori diſcovered, that the phoſphoreſcence of the luciole is a property independent of the life of theſe animals, and that it is chiefly owing to the ſoft ſtate of the phoſphoric ſubſtance. Its light is ſuſpended by drying, and it is again revived by ſoftening it in water; but only after a certain time of deſiccation. Reaumur, Beccaria, and Spallanzani, obſerved the ſame thing in regard to the *pholades* and the *meduſa*.

By plunging the luciole alternately into lukewarm and cold water, they ſhine with vivacity in the former, but their light becomes extinct in the latter; which, according to the author, depends on the alternate agreeable and diſagreeable ſenſation which they experience. In warm water their light diſappears gradually. Dr Carradori tried on the luciole and their phoſphorus the action of different ſaline and ſpirituous liquors, in which they exhibited the ſame appearances as other phoſphoric animals. Theſe laſt experiments prove that the phoſphoric

Ludamar.

phofphoric matter of the luciole is only foluble in water.

LUDAMAR, a Moorifh kingdom in the interior of Africa, of which the capital Benorm is placed by Major Rennel in 15° N. lat. and 6° 50′ W. Long. It has for its northern boundary the great defart (fee SAHARA in this *Supplement*), and is defcribed by Mr Park as little better than a defert itfelf. Our traveller was taken captive on the confines of this kingdom, and carried to the camp of the king, where he was fubjected to the cruelleft indignities that the malice of bigotted Moors could invent. He was not fuffered to travel beyond the camp; though he moved as it moved, and of courfe faw a confiderable part of the country, and had an opportunity of obferving the manners of the people. "The Moors of Ludamar fubfift chiefly on the flefh of their cattle; and are always on the extreme of either gluttony or abftinence. In confequence of the frequent and fevere fafts which their religion enjoins, and the toilfome journeys which they fometimes undertake acrofs the defert, they are enabled to bear both hunger and thirft with furprifing fortitude; but whenever opportunities occur of fatisfying their appetite, they generally devour more at one meal than would ferve an European for three. They pay but little attention to agriculture; purchafing their corn, cotton cloth, and other neceffaries, from the Negroes, in exchange for fat, which they dig from the pits in the Great Defert.

"The natural barrennefs of the country is fuch, that it furnifhes but few materials for manufacture. The Moors, however, contrive to weave a ftrong cloth, with which they cover their tents; the thread is fpun by their women from the hair of goats: and they prepare the hides of their cattle fo as to furnifh faddles, bridles, pouches, and other articles of leather. They are likewife fufficiently fkilful to convert the native iron, which they procure from the Negroes, into fpears and knives, and alfo into pots for boiling their food; but their fabres and other weapons, as well as their fire-arms and ammunition, they purchafe from the Europeans, in exchange for the Negro flaves which they obtain in their predatory excurfions. Their chief commerce of this kind is with the French traders on the Senegal river."

The Moors of this country have fingular ideas of feminine perfection. The gracefulnefs of figure and motion, and a countenance enlivened by expreffion, are by no means effential points in their ftandard; with them corpulence and beauty appear to be terms nearly fynonymous. A woman, of even moderate pretenfions, muft be one who cannot walk without a flave under each arm to fupport her; and a perfect beauty is a load for a camel. In confequence of this prevalent tafte for unwieldinefs of bulk, the Moorifh ladies take great pains to acquire it early in life; and for this purpofe many of the young girls are compelled by their mothers to devour an immenfe quantity of food, and drink a large bowl of camel's milk every morning. It is of no importance whether the girl has an appetite or not, the meat and the drink muft be fwallowed; and obedience is frequently enforced by blows. This fingular practice, inftead of producing indigeftion and difeafe, foon covers the young lady with that degree of plumpnefs, which, in the eye of a Moor, is perfection itfelf.

Ludamar ‖ Lynx.

"Although the wealth of the Moors confifts chiefly in their numerous herds of cattle; yet, as the paftoral life does not afford full employment, the majority of the people are perfectly idle, and fpend the day in trifling converfation about their horfes, or in laying fchemes of depredation on the Negro villages.

"The ufual place of rendezvous for the indolent is the king's tent, where great liberty of fpeech feems to be exercifed by the company towards each other. While in fpeaking of their chief, they exprefs but one opinion. In praife of their fovereign, they are unanimous. Songs are compofed in his honour, which the company frequently fing in concert; but they are fo loaded with grofs adulation, that no man but a Moorifh defpot could hear them without blufhing. The king is diftinguifhed by the finenefs of his drefs, which is compofed of blue cotton cloth brought from Tombuctoo, or white linen or muflin from Morocco. He has likewife a larger tent than any other perfon, with a white cloth over it; but in his ufual intercourfe with his fubjects, all diftinctions of rank are frequently forgotten. He fometimes eats out of the fame bowl with his camel-driver, and repofes himfelf, during the heat of the day, upon the fame bed.

"The military ftrength of Ludamar confifts in cavalry. They are well mounted, and appear to be very expert in fkirmifhing and attacking by furprife. Every foldier furnifhes his own horfe, and finds his accoutrements, confifting of a large fabre, a double barrelled gun, a fmall red leather bag for holding his balls, and a powder-horn flung over the fhoulder. He has no pay, nor any remuneration but what arifes from plunder. This body is not very numerous; for when Ali the king made war upon Bambara, our author was informed that his whole force did not exceed 2000 cavalry. They conftitute, however, by what he could learn, but a very fmall proportion of his Moorifh fubjects. The horfes are very beautiful, and fo highly efteemed, that the Negro princes will fometimes give from twelve to fourteen flaves for one horfe."

Cut off from all intercourfe with civilized nations, and boafting an advantage over the Negroes, by poffeffing, though in a very limited degree, the knowledge of letters, the Moors of Ludamar are at once the vaineft and proudeft, and perhaps the moft bigotted, ferocious, and intolerant of all the nations on the earth; combining in their character the blind fuperftition of the Negro with the favage cruelty and treachery of the Arab. It was with the utmoft difficulty that our author made his efcape from this inhofpitable people.

LUPUS, the *Wolf*, a fouthern conftellation, joined to the Centaur, containing together 19 ftars in Ptolomy's catalogue, but 24 in the Britannic catalogue.

LYNX, a conftellation of the northern hemifphere, compofed by Hevelius out of the unformed ftars. In his catalogue it confifts of 19 ftars, but in the Britannic 44.

MACHINERY,

PLATE XXX.

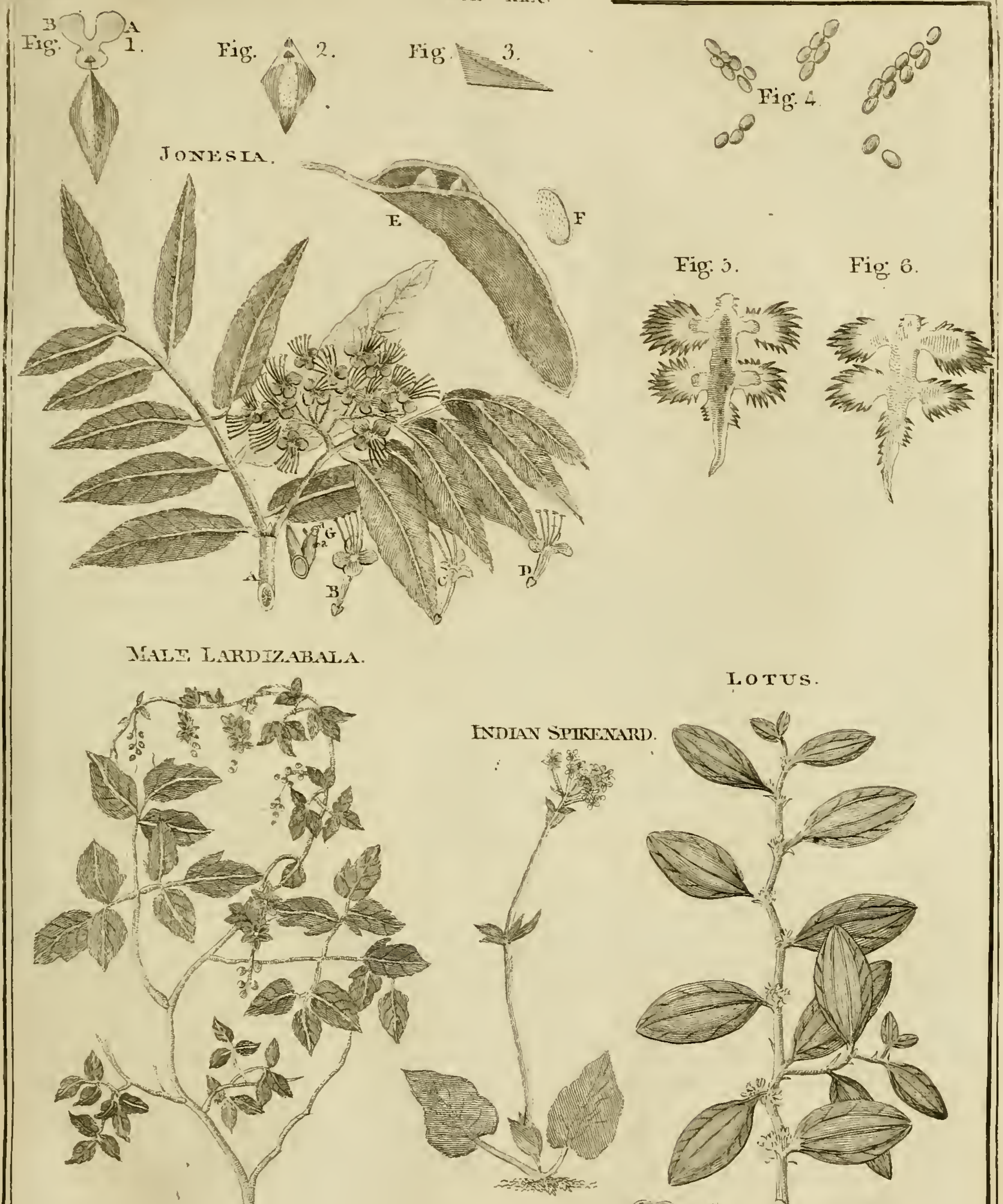


Fig. 1.
B
A
Fig. 2.
Fig. 3.
Fig. 4.
JONESIA.
E
F
G
A
B
C
D
Fig. 5.
Fig. 6.
MALE LARDIZABALA.
LOTUS.
INDIAN SPIKENARD.

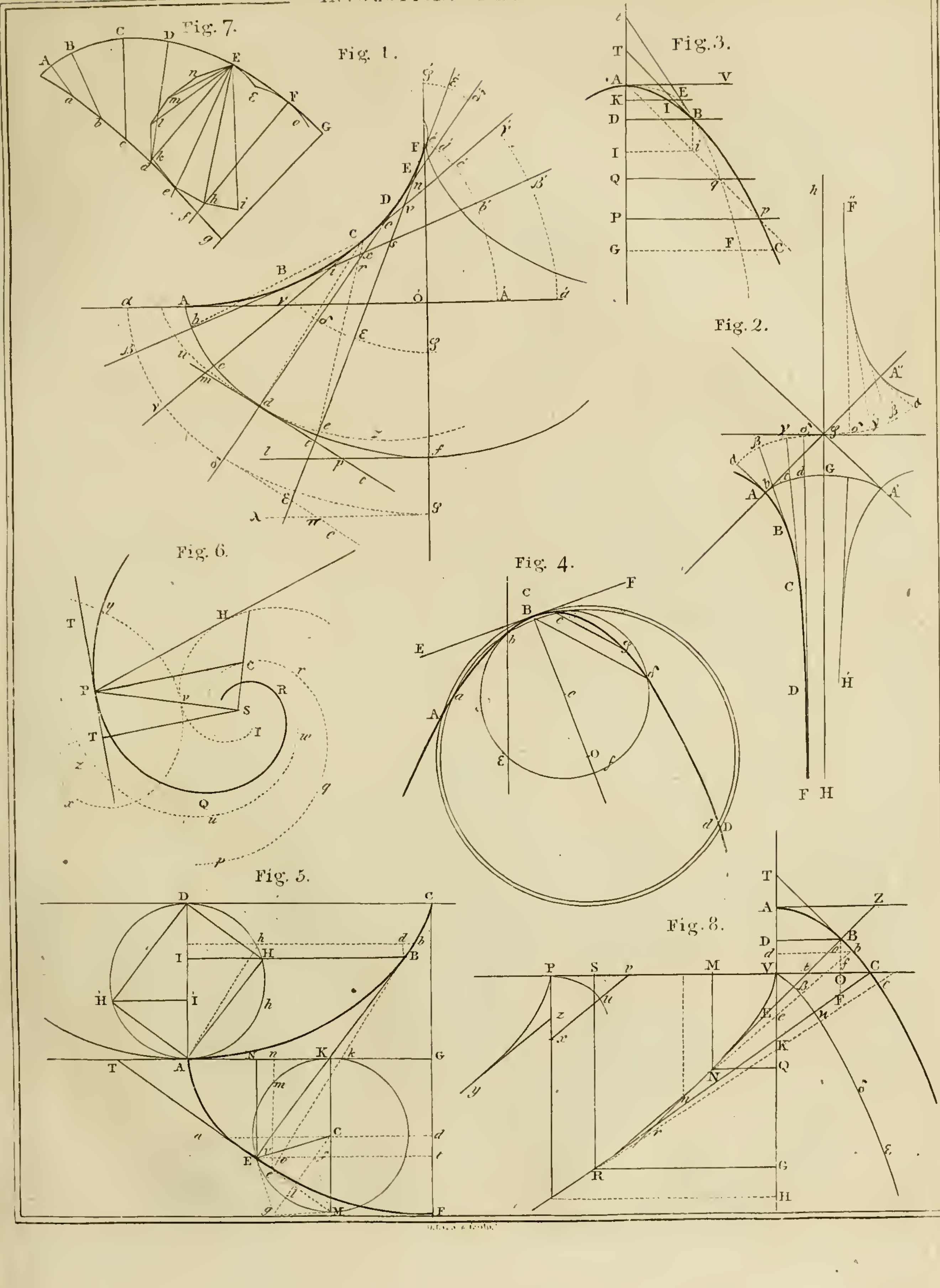


Fig. 7.
Fig. 1.
Fig. 3.
Fig. 2.
Fig. 6.
Fig. 4.
Fig. 5.
Fig. 8.

PLATE XXXII.

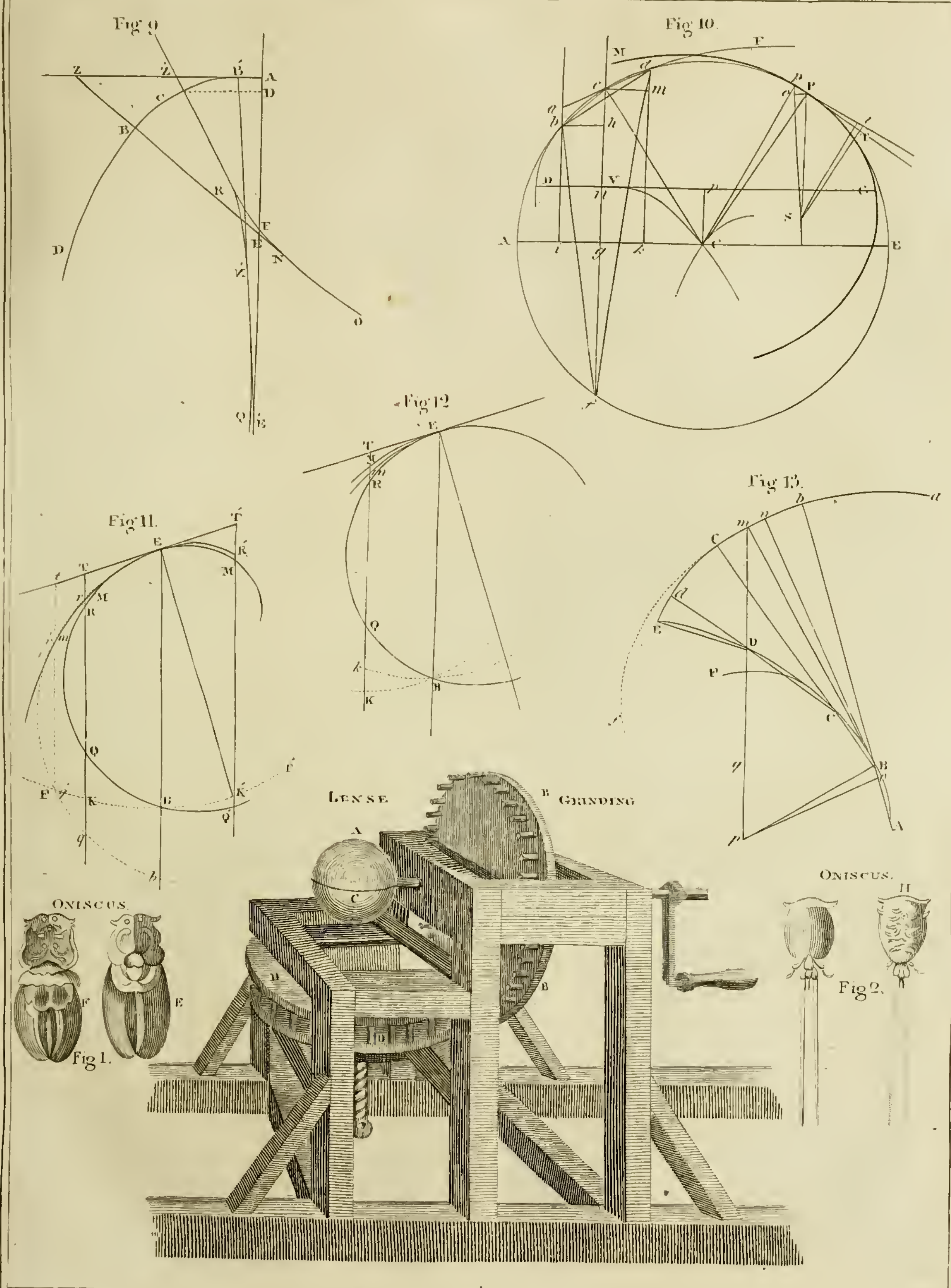


Fig 9.
Fig 10.
Fig 12
Fig 11.
Fig 13.
LENSE GRINDING
ONISCUS.
Fig 1.
ONISCUS.
Fig 2.

M.

MACHINERY.

THE denomination *Machine* is now vulgarly given to a great variety of fubjects, which have very little analogy by which they can be claffed with propriety under any one name. We fay a travelling machine, a bathing machine, a copying machine, a thrafhing machine, an electrical machine, &c. &c. The only circumftance in which all thefe agree feems to be, that their conftruction is more complex and artificial than the utenfils, tools, or inftruments which offer themfelves to the firft thoughts of uncultivated people. They are more artificial than the common cart, the bathing tub, or the flail. In the language of ancient Athens and Rome, the term was applied to every tool by which hard labour of any kind was performed; but in the language of modern Europe, it feems reftricted either to fuch tools or inftruments as are employed for executing fome philofophical purpofe, or of which the conftruction employs the fimple mechanical powers in a confpicuous manner, in which their operation and energy engage the attention. An electrical machine, a centrifugal machine, are of the firft clafs; a thrafhing machine, a fire machine, are of the other clafs. It is nearly fynonymous, in our language, with ENGINE; a term altogether modern, and in fome meafure honourable, being beftowed only, or chiefly, on contrivances for executing work in which ingenuity and mechanical fkill are manifeft. Perhaps, indeed, the term *engine* is limited, by careful writers, to machines of confiderable magnitude, or at leaft of confiderable art and contrivance. We fay, with propriety, fteam-engine, fire-engine, plating engine, boring engine; and a dividing machine, a copying machine, &c. Either of thefe terms, *machine* or *engine*, are applied with impropriety to contrivances in which fome piece of work is not executed on materials which are then faid to be manufactured. A travelling or bathing machine is furely a vulgarifm. A machine or engine is therefore a TOOL; but of complicated conftruction, peculiarly fitted for expediting labour, or for performing it according to certain invariable principles: And we fhould add, that the dependence of its efficacy on mechanical principles muft be apparent, and even confpicuous. The contrivance and erection of fuch works conftitute the profeffion of the engineer; a profeffion which ought by no means to be confounded with that of the mechanic, the artifan, or manufacturer. It is one of the *artes liberales;* as deferving of the title as medicine, furgery, architecture, painting, or fculpture. Nay, whether we confider the importance of it to this flourifhing nation, or the fcience that is neceffary for giving eminence to the profeffor, it is very doubtful whether it fhould not take place of the three laft named, and go *pari paffu* with furgery and medicine. The inconfiderate reader, who perufes *Cicero de Oratore* with fatisfaction, is apt to fmile at Vitruvius, who requires in his architect nearly the fame accomplifhments which Cicero requires in his orator. He has not recollected, or perhaps did not know, that the profeffion of an architect in the Auguftan age was the moft refpectable of all thofe which were not effentially connected with the management of ftate affairs. It appears that the architects were all Greeks, or the pupils of Greeks, altogether different from the members of the *Collegium Murariorum*, the corporation of builders and mafons. The architecture of temples, ftadiums, circufes, amphitheatres, feems to have been monopolifed, by ftate authority, by a fociety which had long fubfifted in Afia, connected by certain myfterious bonds, both civil and religious. We find it in Syria; and we learn that it was brought thither from Perfia in very ancient times. From thence it fpread into Ionia, where it became a very eminent and powerful affociation, under the particular protection of Bacchus, to whom the members had erected a magnificent temple at Teos, with a vaft eftablifhment of priefts and priefteffes, confifting of perfons of the firft rank in the ftate. They were the fole builders of temples and ftadiums throughout all Greece and the Leffer Afia; and the contractors for the machinery that was employed in the theatres, and in the great temples, for the celebration of the high myfteries of paganifm. By the imperfect accounts which remain of the Eleufinian and other myfteries, it appears, that this machinery muft have been immenfe and wonderful, and muft have required a great deal of mechanical fkill. This indeed appears, in the moft convincing manner, to any perfon who reflects on the magnificent ftructures which they erected, which excite to this day the wonder of the world, not only on account of their magnificence and incomparable elegance, but alfo on account of the mechanical knowledge that feems indifpenfably neceffary for their erection. This will ever remain a myftery. There are no traces of fuch knowledge to be found in the writings of antiquity. Even Vitruvius, writing exprefsly on the fubject, has given us nothing but what is in the loweft degree of elementary knowledge.

This affociation of the Dionyfiacs undoubtedly kept their mechanical fcience a profound fecret from the uninitiated, the profane. They were the engineers of antiquity, and Vitruvius was perhaps not one of the initiated. He fpeaks of Myro and other Greek architects in terms of refpect which border on veneration. Perhaps the modern affociation of free mafons is a remain of this ancient fraternity, continued to our times by the company of builders, who erected the cathedrals and great conventual churches. No one who confiders their works with fcientific attention, can doubt of their being deeply verfed in the principles of mechanics, and even its more refined branches. They appear to have carried the art of vault-roofing almoft to its acmé of perfection; far outftripping their Grecian inftructors in their knowledge of this moft delicate branch of their art.

It were greatly to be wifhed that fome fuch inftitution did yet exift, where men might be induced by the moft powerful motives to accomplifh themfelves in the knowledge neceffary for attaining eminence in their profeffion.

We have been informed (and we thought our authority good), that our gracious Sovereign has fignified his intention of patronifing an inftitution of this kind. We heard, that it was propofed to inftitute degrees fimilar to our univerfity degrees, and proceeding on fimilar conditions of a regular education or ftanding, which would enfure the *opportunities* of information, and alfo on an examination of the proficiency of the candidate. This examination, being conducted by perfons eminent in the profeffion, perhaps ftill exercifing it, would probably be ferious, becaufe the fuccefsful candidate would immediately become a rival practitioner. Such an inftitution would undoubtedly prevent many grofs impofitions by unlettered mill-wrights and pump-makers, who now feldom appear under any name but that of engineer, although they are frequently ignorant even of the elements of mechanical fcience, and are totally unacquainted with the higher mathematics; without which it is abfolutely impoffible for them to contrive a machine well fuited to the intended puropofe, or to fay with any tolerable precifion what will be the performance of the engine they have erected. Yet thefe are queftions fufceptible of accurate folution, becaufe they depend on the unalterable laws of matter and motion.

All who have a juft view of the unfpeakable advantages which this highly favoured land poffeffes in the fuperiority and activity of its manufactures, and who know how much of this fuperiority fhould be afcribed to the great improvements which have been made in practical mechanics within thefe laft thirty years, will join us in wifhing fuccefs to fome fuch inftitution as that now mentioned.

We were naturally led to thefe reflections when we turned our thoughts to machinery in general, and obferved what is done in this country by the native energy of its inhabitants, unaffifted by fuch fcientific inftructions as they might have expected from the pupils of a Newton, their countryman, under the patronage of the beft of Sovereigns, eminently knowing in thefe things, and ever ready to encourage thofe fciences and arts which have fo highly contributed to the national profperity. What might not be reafonably expected from Britifh activity, if thofe among ourfelves who have knowledge and leifure had been at the fame pains with the members of the foreign academies to cultivate the Newtonian philofophy, and particularly the more refined branches of mechanics, and to deduce from their fpeculations maxims of conftruction fitted to our fituation as a great manufacturing nation? But fuch knowledge is not attainable by thofe who are acquainted only with the imperfect elements contained in the publications read by the bulk of our practitioners. Much to this purpofe has been done on the continent by the moft eminent mathematicians; but from want of individual energy, or perhaps of general fecurity and protection, the patriotic labours of thofe gentlemen have not done the fervice to their country which might have been reafonably expected. Indeed, their differtations have generally been fo compofed, that only the learned could fee their value. They feem addreffed only, or chiefly, to fuch; but it is to thofe authors that our countrymen generally have recourfe for information concerning every thing in their profeffion that rifes above mere elementary knowledge. The books in our language which profefs to be fyftems of mechanics rarely go beyond this: they contain only the principles of equilibrium. Thefe are abfolutely neceffary for the knowledge of machines; but they are very far indeed from giving what may be called a practical knowledge of *working machinery*. This is never in a ftate of equilibrium. The machine muft move in order to work. There muft be a fuperiority of impelling power, beyond what is merely fufficient for balancing the refiftance or contrary action of the work to be performed. The reader may turn to the article Statics in the *Encyclopædia Britannica*, and he will there fee fome farther obfervations on this head. And in the article Mechanics he will find a pretty ample detail of all the ufual doctrines, and a defcription of a confiderable variety of machines or engines, accompanied by fuch obfervations as are neceffary for tracing the propagation or tranfmiffion of preffure from that part of the machine, to which the natural power is applied, to the working part of the machine. Along with thefe two articles, it will be proper to read with peculiar attention the article Rotation.

By far the greateft number of our moft ferviceable engines confift chiefly of parts which have a motion of rotation round fixed axes, and derive all their energy from levers virtually contained in them. And thefe acting parts are alfo material, requiring force to move them, over and above what is neceffary for producing the acting force at the working part of the machine. The modifications which this circumftance frequently makes of the whole motions of the machine, are indicated in the article Rotation in an elementary way; and the propofitions there inveftigated will be found almoft continually involved in the complete theory of the operation of a machine. Laftly, it will be proper to confider attentively the propofitions contained in the article *Strength of Materials*, that we may combine them with thofe which relate wholly to the working of the machine; becaufe it is from this combination only that we difcover the ftrains which are excited at the various points of fupport, and of communication, and in every member of the machine. We fuppofe all thefe things already underftood.

1 The chief queftion in mechanics.

Our object at prefent is to point out the principles which enable us to afcertain what will be the precife motion of a machine of given conftruction, when actuated by a natural power of known intenfity, applied to a given point of the machine, while it is employed to overcome a known refiftance acting at another point. To abbreviate language, we fhall call that the impelled point of the machine to which the preffure of the moving power is immediately applied; and we may call that the working point, where the refiftance arifing from the work to be performed immediately acts.

To confider this important fubject, even in its chief varieties, requires much more room than can be allowed in an undertaking like ours, and therefore we muft content ourfelves with a very limited view; but at the fame time, fuch a view as fhall give fufficient indication of the principles which fhould direct the practical reader in every important cafe. We fhall confider thofe machines which

which perform their motions round fixed axes; thefe being by far the moft numerous and important, becaufe they involve in their conftruction and operations all the leading principles.

2 The proper meafure of mechanical power explained.

That we may proceed fecurely, it is neceffary to have a precife and adequate notion of moving force, as applied to machinery, and of its meafures. We think this peculiarly neceffary. Different notions have been entertained on this fubject by Mr Leibnitz, Des Cartes, and other eminent mechanicians of the laft century; and their fucceffors have not yet come to an agreement. Nay, fome of the moft eminent practitioners of the prefent times (for we muft include Mr Smeaton in the number) have given meafures of mechanical power in machinery which we think inaccurate, and tending to erroneous conclufions and maxims.

We take for the meafure (as it is the effect) of exerted mechanical power the quantity of motion which it produces by its uniform exertion during fome given time. We fay *uniform exertion*, not becaufe this uniformity is neceffary, but only becaufe, if any variation of the exertion has taken place, it muft be known, in order to judge of the power. This would needlefsly complicate the calculations; but in whatever way the exertion may have varied, the whole accumulated exertion is ftill accurately meafured by the quantity of motion exifting at the end of the exertion. The reader muft perceive that this is the fame thing that is expreffed in the article DYNAMICS of this *Supplement*, nº 90. by the area of the figure whofe abfciffa or axis reprefents the time of exertion; and the ordinates are as the preffures in the different inftants of that time, the whole being multiplied by the number of particles (that is, by the quantity of matter), becaufe that figure reprefents the quantity of motion generated in one particle of matter only. All this is abundantly clear to perfons converfant in thefe difquifitions; but we wifh to carry along with us the diftinct conceptions of that ufeful clafs of readers whofe profeffion engages them in the conftruction and employment of machines, and to whom fuch difcuffions are not fo familiar. We muft endeavour therefore to juftify our choice of this meafure by appealing to familiar facts.

If a man, by preffing uniformly on a mafs of matter for five feconds, generates in it the velocity of eight feet per fecond, we obtain an exact notion of the proportion of this exertion to the mechanical exertion of gravity, when we fay that the man's exerted force has been precifely one-twentieth part of the action of gravity on it; for we know that the weight of that body (or, more properly, its heavinefs) would, in five feconds, have given it the velocity of 160 feet per fecond, by acting on it during its fall. But let us attend more clofely to what we mean by faying that the exerted force is one-twentieth of the exertion of gravity. The only notion we have of the exertion of gravity is what we call the weight of the body—the preffure which we feel it make on our hand. To fay that this is 20 pounds weight, does not explain it; becaufe this is only the action of gravity on another piece of matter. Both preffures are the fame. But if the body weighs 20 pounds, it will draw out the rod of a fteelyard to the mark 20. The rod is fo divided, that the 20th part of this preffure will draw it out to 1. Now the fact is, that if the man preffes on the mafs of 20 pounds weight with a fpring fteelyard during five feconds, and if during that time the rod of the fteelyard was always at the mark 1, the body will have acquired the velocity of eight feet per fecond. This is an acknowledged fact. Therefore we were right in faying, that the man's exertion is one-twentieth of the exertion of gravity. And fince we believe the weight of bodies to be proportional to their quantity of matter, all matter being equally heavy, we may fay, that the man's exertion was equal to the action of gravity on a quantity of matter whofe weight is one pound. We exprefs it much more familiarly, by faying, that the man exerted on it the preffure of one pound of matter, or the force of one pound.

In this manner, the motion communicated to a mafs of matter, by acting on it during fome time, informs us with accuracy of the real mechanical force or preffure which has been exerted. This is judged to be double when twice the velocity has been generated in the fame mafs, or where the fame velocity has been generated in twice the mafs; becaufe we know, that a double preffure would have done either the one or the other.

But farther: We know that this preffure is the exertion; we have no other notion of our own force; and our notion of gravity, of elafticity, or any other natural force, is the fame. We alfo know that the continuance of this exertion fatigues and exhaufts our ftrength as completely as the moft violent motion. A dead pull, as it is called, of a horfe, at a poft fixed in the ground, is a ufual trial of his ftrength. No man can hold out his arm horizontally for much more than a quarter of an hour; and the exertion of the laft minutes gives the moft diftreffing fatigue, and difables the fhoulder from action for a confiderable time after. This is therefore an expenditure of mechanical power, in the ftrict primitive fenfe of the word. Of this expenditure we have an exact and adequate effect and meafure in the quantity of motion produced; that is, in the product of the quantity of matter by the velocity generated in it by this exertion. And it muft be particularly noticed, that this meafure is applicable even to cafes where no motion is produced by the exertion; that is, if we know that the exertion which is juft unable to ftart a block of ftone lying on a fmooth ftone pavement, but would ftart it, if increafed by the fmalleft addition; and if we know that this would generate in a fecond 32 feet of velocity in 100 pounds of matter—we are certain that it was a preffure equal to the weight of this 100 pounds. It is a good meafure, though not immediate, and may be ufed without danger of miftake when we have no other.

3 Mr Smeaton's meafure.

The celebrated engineer Mr Smeaton, in his excellent differtation on the power of water and wind to drive machinery, and alfo in two other differtations, all publifhed in the Philofophical Tranfactions, and afterwards in a little volume, has employed another meafure, both of the expenditure of mechanical power, and of the mechanical effect produced. He fays, that the weight of a body, multiplied by the height thro' which it defcends, while driving a machine, is the only proper meafure of the power expended; and that the weight, multiplied by the height through which it is uniformly raifed, is the only proper meafure of the effect produced. And he produces a large train of accurate experiments;

riments to prove that a certain weight, deſcending through a certain ſpace, always produces the ſame effect, whether it has deſcended ſwiftly or ſlowly, employing little or much time.

Had this eminent engineer propoſed this as a popular meaſure, of eaſy comprehenſion and remembrance, and as well accommodated to the uſes of thoſe engaged in the conſtruction of machines, when reſtricted to a certain claſs of caſes, it might have anſwered very good purpoſes; but the author is at pains to recommend it to the philoſophers as a neceſſary correction of their theories, which he ſays tends to miſlead the artiſts. His own reaſonings terminate in the ſame concluſion with Mr Leibnitz's, namely, that the power of producing a mechanical effect, and the effect produced, are proportional to the ſquare of the velocity. The difference juſtly due to Mr Smeaton's authority, and the influence of his name among thoſe who are likely to make the moſt uſe of his inſtructions, render it neceſſary for us to examine this matter with ſome attention.

Mr Smeaton was led to the adoption of this meaſure by his profeſſional habits. Raiſing a weight to a height is, in one ſhape or another, the general taſk of the machines he was employed to erect; and we may add, the opportunities of expending the mechanical powers of nature which are in our command, are generally in this proportion. A certain daily ſupply of water, coming from a certain height, is our beſt opportunity, and may very properly be ſaid to be expended.

4 Examined.

This being the general caſe, the meaſure was obvious, and natural, and good. The power and effect were of the ſame kind, and *muſt* be meaſures of each other; at leaſt in thoſe circumſtances in which they were ſet in oppoſition. Yet even here Mr Smeaton was obliged to make a reſtriction of his meaſures: "The height thro' which a body *ſlowly and equably* deſcended, or to which it was raiſed." And why was this limitation neceſſary? "Becauſe in rapid or accelerated motions, the inertia of bodies occaſioned ſome variation*." But this is too vague language for philoſophical diſquiſition. Beſides, what is meant by this variation? What is the ſtandard from which the unreſtricted meaſure varies? This ſtandard, whatever it is, is the true meaſure, and it was needleſs to adopt any other. Now, the ſtandard from which Mr Smeaton eſtimates the deviation, is the very meaſure which we wiſh to employ, namely, the quantity of motion produced. Strictly ſpeaking, even this is not the immediate meaſure. The immediate meaſure is that faculty which we call preſſure. This is the intermedium perceivable in all productions of motion; and it is alſo the intermedium of mechanical effect, even when motion is not produced; as when the weight of a body bends a ſpring, or the elaſticity of a body ſupports another preſſure. How it operates in all or any of theſe caſes, we know not; but we know that all theſe meaſures of preſſure agree with each other. A double quantity of motion will bend a ſpring doubly ſtrong, will raiſe a double weight, will withſtand any double preſſure, &c. &c. In ſhort, preſſure is the immediate agent in every mechanical phenomenon. It penetrates bodies, overcoming their tenacity; it overcomes friction; it balances preſſure; it produces motion. Mr Smeaton's meaſure is only nearly true, in any caſe, and in all caſes it is far from being exact in the firſt inſtants of the motion, during its acceleration or retardation.

* Page 70.

We have already noticed the complete expenditure of animal power by continued preſſure, even when motion is not produced: the only difficulty is to connect this in a meaſurable way with the power which the ſame exertion has of generating motion in a body.

When a man ſupports a weight for a ſingle inſtant, he certainly balances the preſſure or action of gravity on that body; and he continues this action as long as he continues to ſupport it: and we know that if this body were at the end of a horizontal arm turning round a vertical axis, the ſame effort which the man exerted in merely carrying the weight, if now exerted on the body, by puſhing it horizontally round the axis, will generate in it the ſame velocity which gravity would generate by its falling freely. On this authority therefore we ſay, that the whole accumulated action of a man, when he has juſt carried a body whoſe weight is 30 pounds for one minute, is equal to the whole exertion of gravity on it during that minute; and if employed, not to counteract gravity, but to generate motion, would generate, during the minute, the ſame motion that gravity would, that is, 60×32 feet velocity per ſecond, in a maſs of 30 pounds. There would be 30 pounds of matter moving with the velocity of 1920 feet per ſecond. We would expreſs this production or effect by 30×1920, or by 57600, as the meaſure of the man's exertion during the minute.

But, according to Mr Smeaton, there is no expenditure of power, nor any production of mechanical effect, in thus carrying 30 pounds for a minute; there is no product of a weight by a height through which it is equably raiſed; yet ſuch exertion will completely exhauſt a man's ſtrength if the body be heavy enough. Here then is a caſe to which Mr Smeaton's meaſure does not readily apply; and this caſe is important, including all the actions of animals at a dead pull.

But let us conſider more narrowly what a man really does when he performs what Mr Smeaton allows to be the production of a meaſurable mechanical effect. Suppoſe this weight of 30 pounds hanging by a cord which paſſes over a pulley, and that a man, taking this cord over his ſhoulder, turns his back to the pulley, and walks away from it. We know, that a man of ordinary force will walk along, raiſing this weight, at the rate of about 60 yards in a minute, or a yard every ſecond, and that he can continue to do this for eight or ten hours from day to day; and that this is all that he can do without fatigue. Here are 30 pounds raiſed uniformly 180 feet in a minute; and Mr Smeaton would expreſs this by 30×180, or 5400, and would call this the meaſure of the mechanical effect, and alſo of the expenditure of power. This is very different from our meaſure 57600.

5 And found to be inaccurate.

But this is not an accurate and complete account of the man's *action* on the weight, and of the whole effect produced. To be convinced of this, ſuppoſe that a man A has been thus employed, while another B, walking along ſide of him at the ſame rate, ſuddenly takes the rope out of his hand, frees him of the taſk, and *continues* to raiſe the weight without the ſmalleſt change on its velocity of aſcent. What is the action of B, and whether is it the ſame with that of A or not? It is acknowledged by all, that the exertion of B againſt the load is preciſely equal to 30 pounds. If he holds the rope by a ſpring ſteelyard, it will ſtand conſtantly at the mark 30. B exerts the ſame action on the load as when

when he simply supports it from falling back into the pit. It was moving with the velocity of three feet per second when he took hold of the rope, and it would continue to move with that velocity if any thing could annihilate or counteract its gravity. If therefore there was no action when a person merely carried it, there is none at present when it is rising 180 feet in a minute. The man does indeed work more than on that occasion, but not against the load; his additional work is walking, the motion of his own body, as a thing previously necessary that he may continue to support the load, that he may continue his mechanical effort as it follows him. It appears to yield to him: but it is not to *his* efforts that it yields; its weight completely balances those efforts, and is balanced by them. It was to a *greater* effort of the man A that it yielded. It was then lying on the ground. He pulled at the cord, gradually perhaps increasing his pull till it was just equal to its weight. When this obtains, the load no longer presses on the ground, but is completely carried by the rope. But it does not move by this effort of 30 pounds; but let him exert a force of 31 pounds, and continue this for three seconds. He will put it in motion; will accelerate that motion; and at the end of three seconds the load is rising with the velocity of three feet per second. The man feels that this as much speed as he can continue in his walk; he therefore slackens his pull, reducing his action to 30 pounds, and with this action he walks on. All this would be distinctly perceived by means of a steelyard. The rod would be pulled out beyond 30, till the load acquired the uniform velocity intended, and after this it would be observed to shrink back to 30.

More is done therefore than appears by Mr Smeaton's measure. Indeed, all that appears in it is the exertion necessary for *continuing* a motion already produced, but which would be immediately extinguished by a contrary power, which must therefore be counteracted. This measure will not apply to numberless cases of the employment of machines, where there is no such opposing power, and where, notwithstanding, mechanical power must be expended, even according to Mr Smeaton's measurement. Such are corn mills, boring mills, and many others.

How then comes it that Mr Smeaton's valuable experiments concur so exactly in shewing that the same quantity of water descending from the same height, always produces the same effect (as he measured it), whatever be the velocity? In the first place, all his experiments are cases where the power expended and the work performed are of the same kind: A heavy body descends, and by its preponderancy raises another heavy body. But even this would not ensure the precise agreement observed in his experiments, if Mr Smeaton were not careful to exclude from his calculations all that motion where there is any acceleration, and all the expenditure of water during the acceleration, and to admit only those motions that are sensibly uniform. In moderate velocities, the additional pressure required for the first acceleration is but an insignificant part of the whole; and to take these accelerated motions into the account, would have embarrassed the calculations, and perhaps confused many of the readers. We see, in the instance now given, that the addition of one pound continued for three seconds only, was all that was necessary.

Mr Smeaton's measurement is therefore abundantly exact for practice; and being accommodated to the circumstances most likely to engage the attention, is very proper for the instruction of the numerous practitioners in all manufacturing countries who are employed for ordinary erections; but it is improperly proposed as an article essential to a just theory of mechanics, and therefore it was proper to notice it in this place. Besides, there frequently occur most important cases, in which the motion of a machine is, of necessity, desultory, alternately accelerated, and retarded. We should not derive all the advantages in our power from the first mover, if we did not attend particularly, and chiefly, to the *accelerating* forces. And in every case, the improvement, or the proper employment of the machine, is not attained, if we are not able to discriminate between the two parts of the mechanical exertion; one of them, by which the motion is produced and accelerated to a certain degree; and the other, by which that motion is continued. We must be able to appreciate what part of the effect belongs to each. But it is now time to proceed to the important question,

What will be the precise motion of a machine of given construction, actuated by a power of known intensity and manner of acting, and opposed by a known resistance?

6 Things to be considered in a machine at work.

In the solution of this question, much depends on the nature of both power and resistance. In the statical consideration of machines, no attention is paid to any differences. The intensity of the pressures is all that it is necessary to regard, in order to state the proportion of pressure which will be exerted in the various parts of the machine. The pressures at the impelled and working points, combined with the proportions of the machine, necessarily determine all the rest. Pressure being the sole cause of all mechanical action among bodies, any pressure may be substituted for another that is equal to it; and the pressure which is most familiar, or of easiest consideration, may be used as the representative of all others. This has occasioned the mechanical writers to make use of the pressure of gravity as the standard of comparison, and to represent all powers and resistances by weights. However proper this may be in their hands, it has hurt the progress of the science. It has rendered the usual elementary treatises of mechanics very imperfect, by limiting the experiments and illustrations to such as can be so represented with facility. This has limited them to the state of equilibrium (in which condition a working machine is never found), because illustrations by experiment out of this state are neither obvious nor easy. It has also prevented the students of mechanics from accomplishing themselves with a mathematical knowledge required for a successful prosecution of the study. The most elementary geometry is sufficient for a thorough understanding of equilibrium, or the doctrines of statics; but true mechanics, the knowledge of machines as instruments by which work is performed, requires more refined mathematics, and is inaccessible without it.

Had not Newton or others improved mathematics by the invention of the infinitesimal analysis and calculus, we must have rested contented with the discoveries (really great) of Galileo and Huyghens. But Newton,

ton, *suâ mathesi facem præferente*, opened a boundless field of investigation, and has not only given a magnificent and brilliant specimen of the discoveries to be made in it, but has also traced out the particular paths in which we are to find the solution of all questions of practical mechanics. This he has done by shewing another species of equilibrium, indicated, not by the cessation of all motion, but by the uniformity of motion; by the cessation of all acceleration or retardation. As the extinction of motion by the action of opposite forces is assumed by us as the indication of the perfect equality of those forces; so the extinction of acceleration should be received as the indication of something equal and opposite to the force which was known to have caused the acceleration; and therefore as the indication of an equilibrium between opposite forces, or else of the cessation of all force.

7 Mechanical equilibrium

This new view of things was the source of all our distinct notions of mechanical forces, and gave us our only unexceptionable marks and measures of them. The 39th proposition of the first book of Newton's Principles of Natural Philosophy, and its corollaries, contain almost the whole doctrine of active mechanical nature, and are peculiarly applicable to our present purpose, because they enable us to comprehend in this *mechanical equilibrium* (so different from the *statical*) every circumstance in which those pressures which are exerted by natural powers differ from each other, and vary in their action on the impelled and working points of a machine. Indeed, when we recollect that the operations of our machines are the same on board a ship as on shore, and that all our machines are moving with the ground on which they stand, we must acknowledge, that even ordinary statics is only an imperfect view of an equilibrium among things which are in motion; and this should have taught us that, even in those cases where nothing like equilibrium appears, an equilibrium may still be usefully traced.

8 Distinctions must be the made in the nature of the powers applied to working machines.

In the statical consideration of machines, the *quantity* of pressure is all that we need attend to. But in the mechanical discussion of their *operations*, we must attend to their distinctions in kind: and it will by no means be sufficient to represent them all by weights; for their distinction in kind is accompanied by great differences in their manner of acting on the machine. Some natural powers, in order to continue their action on the impelled point of the machine, must at the same time put into motion a quantity of matter external to the machine, in which these powers reside; and this must be made to follow the impelled point in its motion, and not only follow, but continue to press it forward; or, this matter, thus continually put into motion, must be successively applied to different points of the machine, which become impelled points in their turn. This is the case with a weight, with the action of a spring, the action of animals, the action of a stream of water or wind, and many other powers. A part of the natural mechanical powers must therefore be employed in producing this external motion. This is sometimes a very considerable part of the whole natural power. In some cases it is the whole of it. This obtains in the action of a descending weight, lying on the end of a lever and pressing it down, or hanging by a cord attached to the machine.

There is also an important distinction in the manner in which this external motion is kept up. In a weight employed as the moving power, the actuating pressure seems to reside in the matter itself; and all that is necessary for continuing this pressure is merely to continue the connection of it with the machine. But in the action of animals it may be very different: A man pushing at a capstan bar, must first of all walk as fast as the bar moves round, and this requires the expenditure of his muscular force. But this alone will not render his action an effective power: He must also *press forward* the capstan bar with as much force as he has remaining over and above what he expends in walking at that rate. The proportion of these two expenditures may be very different in different circumstances; and in the judicious selection of such circumstances as make the first of these as inconsiderable as possible, lies much of the skill and sagacity of the engineer. In the common operation of thrashing corn, much more than half of the man's power is expended in giving the necessary motion to his own body, and only the remainder is employed in urging forward the swiple with a momentum sufficient for shaking off the ripe grains from the stalk. We had sufficient proof of this, by taking off the swiple of the flail, and putting the same weight of lead on the end of the staff, and then causing the hind to perform the usual motions of thrashing with all the rapidity that he could continue during the ordinary hours of work. We never could find a man who could make three motions in the same time that he could make two in the usual manner, so as to continue this for half an hour. Hence we must conclude, that half (some will say two-thirds) of a thresher's power is expended in merely moving his own body. Such modes of animal action will therefore be avoided by a judicious engineer; but to be avoided, their inconvenience must be understood. More of this will occur hereafter. In other cases we are almost, (never wholly) free from this unprofitable expenditure of power. Thus, in the steam engine, the operation requires that the external air follow the piston down the cylinder, in order to continue its pressure. But the force necessary for sending in this rare fluid into the cylinder with the necessary velocity, is such an insignificant part of the whole force which is at our command, that it would be ridiculous affectation in any engineer to take it into account; and this is one great ground of preference to this natural power. The same thing may be said of the action of a strong and light spring, which is therefore another very eligible first mover for machinery. The ancient artillerists had discovered this, and employed it in their warlike engines.

We must also attend to the nature of the resistance which the work to be performed opposes to the motion of our machine. Sometimes the work opposes, not a simple obstruction, but a real resistance or reaction, which, if applied alone to the machine, would cause it to move the contrary way. This always obtains in cases where a heavy body is to be raised, where a spring is to be compressed, and in some other cases. Very often, however, there is no such contrary action. A flour mill, a saw mill, a boring mill, and many such engines, exhibit no reaction of this kind. But although such machines, when at rest or not impelled by the first mover, sustain no pressure in the opposite direction, yet they

they will not acquire any motion whatever, unleſs they be impelled by a power of a certain determinate intenſity. Thus in a ſaw mill, a certain force muſt be impreſſed on the teeth of the ſaw, that the coheſion of the fibres of the timber may be overcome. This requires that a certain force, determined by the proportions of the machine, be impreſſed on the impelled point. If this, and no more, be applied there, a force will be excited at the teeth of the ſaw, which will *balance* the coheſion of the wood, but will not *overcome* it. The machine will continue at reſt, and no work will be performed. Any addition of force at the impelled point, will occaſion an addition to the force excited in the teeth of the ſaw. The coheſion will be overcome, the machine will move, and work will be performed. It is only this *addition* to the impelling power that gives motion to the machine; the reſt being expended merely in balancing the coheſion of the woody fibres. While therefore the machine is in motion, performing work, we muſt conſider it as actuated by a force impreſſed on the impelled point by the natural power, and by another acting at the working point, furniſhed by or derived from the reſiſtance of the work.

Again: It not unfrequently happens, that there is not even any ſuch reſiſtance or obſtruction excited at the working point of the machine; the whole reſiſtance (if we can with propriety give it that name) ariſes from the neceſſity of giving motion to a quantity of inert and inactive matter. This happens in urging round a heavy fly, as in the coining preſs, in the punching engine, in drawing a body along a horizontal plane without friction, and a few ſimilar caſes. Here the ſmalleſt force whatever, applied at the impelled point, will begin motion in the machine; and the *whole* force ſo applied is conſumed in this ſervice. Such caſes are rare, as the ultimate performance of a machine; but occaſionally, and for a farther purpoſe, they frequently occur; and it is neceſſary to conſider them, becauſe there are many of the moſt important applications of machinery where a very conſiderable part of the force is expended in this part of the general taſk.

Such are the chief circumſtances of diſtinction among the mechanical powers of nature which muſt be attended to, in order to know the motion and performance of a machine. Theſe never occur in the ſtatical conſideration of the machine, but here they are of chief importance.

9 [e inertia / he ma[chine] / [th]e itſelf / [mu]ſt alſo / [be] conſider[ed].]

But farther: The action of the moving power is transferred to the working point through the parts of a machine, which are material, inert, and heavy. Or, to deſcribe it more accurately, before the neceſſary force can be excited at the working point of the machine, the various connecting forces muſt be exerted in the different parts of the machine; and in order that the working point may follow out the impreſſion already made, all the connecting parts or limbs of the machine muſt *be moved*, in different directions, and with different velocities. Force is neceſſary for thus changing the ſtate of all this matter, and frequently a very conſiderable force. Time muſt alſo elapſe before all this can be accompliſhed. This often conſumes, and really waſtes, a great part of the impelling power. Thus, in a crane worked by men walking in a wheel, it acquires motion by ſlow degrees; becauſe, in order to give ſufficient room for the action of the number of men or cattle that are neceſſary, a very capacious wheel muſt be employed, containing a great quantity of inert matter. All of this muſt be put in motion by a very moderate preponderance of the men. It accelerates ſlowly, and the load is raiſed. When it has attained the required height, all this matter, now in conſiderable motion, muſt be ſtopped. This cannot be done in an inſtant with a jolt, which would be very inconvenient, and even hurtful; it is therefore brought to reſt gradually. This alſo conſumes time; nay, the wheel muſt get a motion in the contrary direction, that the load may be lowered into the cart or lighter. This can only be accompliſhed by degrees. Then the tackle muſt be lowered down again for another load, which alſo muſt be done gradually. All this waſtes a great deal both of time and of force, and renders a walking wheel a very improper form for the firſt mover of a crane, or any machine whoſe uſe requires ſuch frequent changes of motion. The ſame thing obtains, although in a lower degree, in the ſteam engine, where the great beam and pump rods, ſometimes weighing very many tons, muſt be made to acquire a very briſk motion in oppoſite directions twice in every working ſtroke. It obtains, in a greater or a leſs degree, in all engines which have a reciprocating motion in any of their parts. Pump mills are of neceſſity ſubjected to this inconvenience. In the famous engine at Marly, about $\frac{19}{20}$ of the whole moving power of ſome of the water wheels is employed in giving a reciprocating motion to a ſet of rods and chains, which extend from the wheels to a ciſtern about three-fourths of a mile diſtant, where they work a ſet of pumps. This engine is, by ſuch injudicious conſtruction, a monument of magnificence, and the ſtruggle of ignorance with the unchangeable laws of Nature. In machines, all the parts of which continue the direction of their motions unchanged, the inertia of a great maſs of matter does no harm; but, on the contrary, contributes to the ſteadineſs of the motion, in ſpite of ſmall inequalities of power or reſiſtance, or unavoidable irregularities of force in the interior parts. But in all reciprocations, it is highly prejudicial to the performance; and therefore conſtructions which admit ſuch reciprocation without neceſſity, are avoided by all intelligent engineers. The mere copying artiſt, indeed, who derives all his knowledge from the common treatiſes of mechanics, will never ſuſpect ſuch imperfections, becauſe they do not occur in the ſtatical conſideration of machines. 10

Laſtly, no machine can move without a mutual rubbing of its parts, at all points of communication; ſuch as the teeth of wheelwork, the wipers and lifts, and the gudgeons of its different axes. In many machines, the ultimate taſk performed by the working point, is either friction, or very much reſembles it. This is the caſe in poliſhing mills, grinding mills, nay, in boring mills, ſaw mills, and others. A knowledge of friction, in all its varieties, ſeems therefore abſolutely neceſſary, even for a moderate acquaintance with the principles of machinery. This is a very abſtruſe ſubject; and although a good deal of attention has been paid to it by ſome ingenious men, we do not think that a great deal has been added to our knowledge of it; nor do the experiments which have been made ſeem to us well calculated to lead us to a diſtinct knowledge of its nature and modifications. It has been conſidered chiefly with a view to diminiſh it as much as poſſible in the communicating parts

And its friction.

parts of machinery, and to obtain ſome general rules for aſcertaining the quantity of what unavoidably remains. Mr Amontons, of the Royal Academy of Sciences at Paris, gave us, about the beginning of this century, the chief information that we have on the ſubject. He diſcovered, that the obſtruction which it gave to motion was very nearly proportional to the force by which the rubbing ſurfaces are preſſed together. Thus he found, that a ſmooth oaken board, laid on another ſmooth board of the ſame wood, requires a force nearly equal to one third of what preſſes the ſurfaces together. Different ſubſtances required different proportions.

11 Meaſure of it by Amontons.

He alſo found, that neither the extent of the rubbing ſurfaces, nor the velocity of the motion, made any conſiderable variation on the obſtruction to motion. Theſe were curious and unexpected reſults. Subſequent obſervations have made ſeveral corrections neceſſary in all theſe propoſitions. This ſubject will be more particularly conſidered in another place; but ſince the deviations from Mr Amontons's rule are not very conſiderable, at leaſt in the caſes which occur in this general conſideration of machines, we ſhall make uſe of it in the mean time. It gives us a very eaſy method of eſtimating the effect of friction on machines. It is a certain proportion of the mutual preſſure of the rubbing ſurfaces, and therefore muſt vary in the ſame proportion with this preſſure. Now, we learn from the principles of ſtatics, that whatever preſſures are exerted on the impelled and working point of the machine, all the preſſures on its different parts have the ſame conſtant proportion to theſe, and vary as theſe vary: Therefore the whole friction of the machine varies in the ſame proportion. But farther, ſince it is found that the friction does not ſenſibly change with the velocity, the force which is juſt ſufficient to overcome the friction, and put the loaded machine in motion, muſt be very nearly the ſame with the force expended in overcoming the friction while the machine is moving with any velocity whatever, and performing work. Therefore if we deduct from the force which juſt puts the loaded machine in motion that part of it which balances the reaction of the impelled point occaſioned by the reſiſtance of the work, or which balances the reſiſtance of the work, the remainder is the part of the impelling power which is employed in overcoming the friction. If indeed the actual reſiſting preſſure of the work varies with the velocity of the working point, all the preſſures, and all the frictions in the different communicating parts of the machine, vary in the ſame proportion. But the law of this variation of working reſiſtance being known, the friction is again aſcertained.

We can now ſtate the dynamical equilibrium of forces in the working machine in two ways. We may either conſider the efficient impelling power as diminiſhed by all that portion which is expended in overcoming the friction, and which only prepares the machine for performing work, or we may conſider the impelling power as entire, and the work as increaſed by the friction of the machine; that is, we may ſuppoſe the machine without friction, and that it is loaded with a quantity of additional reſiſtance acting at the working point. Either of theſe methods will give the ſame reſult, and each has its advantages. We took the laſt method in the ſlight view which we took of this ſubject in the *Encycl.* article ROTATION, nº 64. and ſhall therefore uſe it here.

Suppoſing now this previous knowledge of all theſe variable circumſtances which affect the motion of machines of the rotative kind, ſo that, for any momentary poſition of it while performing work, we know what are the preciſe preſſures acting at the impelled and working points, and the conſtruction of the machine, on which depend the friction, and the momentum of its inertia (expreſſed in the article ROTATION by $\int p r^2$); we are now in a condition to determine its motion, or at leaſt its momentary acceleration, competent to that poſition. Therefore,

Let there be a rotative machine, ſo conſtructed, that while it is performing work, the velocity of its impelled point is to that of its working point as m to n. It is eaſy to demonſtrate, from the common principles of ſtatics, that if a ſimple wheel and axle be ſubſtituted for it, having the radius of the wheel to that of the axle in the ſame proportion of m to n, and having the ſame momentum of friction and inertia, and actuated by the ſame preſſures at the impelled and working points, then the velocities of theſe points will be preciſely the ſame as in the given machine.

12 Compoſition of the formula expreſſing the performance of a machine.

Let p repreſent the intenſity (which may be meaſured by pounds weight) of the preſſure exerted in the moment at the impelled point; and r expreſs the preſſure exerted at the working point by the reſiſtance oppoſed by the work that is then performing. This may ariſe from the weight of a body to be raiſed, from the coheſion of timber to be ſawed, &c. Any of theſe reſiſtances may alſo be meaſured by pounds weight; becauſe we know that a certain number of pounds hung on the ſaw of a ſaw mill, will juſt overcome this coheſion, or overcome it with any degree of ſuperiority. Therefore the impelling power p, and the reſiſtance r, however differing in kind, may be compared as mere preſſures.

Let x repreſent the quantity of inert matter which muſt be urged by the impelling power p, with the ſame velocity as the impelled point, in order that this preſſure p may really continue to be exerted on that point. Thus, if the impelling power is a quantity of water in the bucket of an overſhot wheel, acting by its weight, this weight cannot impel the wheel except by impelling the water. In this way, x may be conſidered as repreſenting the inertia of the impelling power, while p repreſents its preſſure on the machine. In like manner, let y repreſent the quantity of external inert matter which is really moved with the velocity of the working point in the execution of the taſk performed by the machine.

Whatever be the momentum of the inertia of the machine, we can always aſcertain what quantity of matter, attached to the impelled point, or the working point of the wheel and axle, will require the ſame force to give the wheel the ſame angular motion; that is, which ſhall have the ſame momentum of inertia. Let the quantity a, attached to the working point, give this momentum of inertia $a n^2$.

Laſtly, ſuppoſing that the wheel and axle have no friction, let f be ſuch a reſiſtance, that if applied to the working point, it ſhall give the ſame obſtruction as the friction of the machine, or require the ſame force at the impelled point to overcome it.

Theſe

13 Angular motion of the machine.

Theſe things being thus eſtabliſhed, the angular velocity of the wheel and axle, that is, the number of turns, or the portion of a turn, which it will make in a given time, will be proportional to the fraction $\frac{pm - \overline{r+f}n}{xm^2 + \overline{a+y}n^2}$. (I.)—See ROTATION, n° 64, &c. *Encycl.*

Since the whole turns together, the velocities of the different points are as their diſtances from the axis, and may be expreſſed by multiplying the common angular velocity by theſe diſtances. Therefore the above formula, multiplied by m or n, will give the velocity of the impelled or of the working point. Therefore,

14 Velocity of the impelled point.

Velocity of impelled point $= \frac{pm^2 - \overline{r+f}mn}{xm^2 + \overline{a+y}n^2}$. (II.)

15 Velocity of the working point.

Velocity of working point $= \frac{pmn - \overline{r+f}n^2}{xm^2 + \overline{a+y}n^2}$. (III.)

In order to obtain a clear conception of theſe velocities, we muſt compare them with motions with which we are well acquainted. The propoſition being univerſally true, we may take a caſe where gravity is the ſole power and reſiſtance; where, for example, p and r are the weights of the water in the bucket of a wheel, and in the tub that is raiſed by it. In this caſe, $p = x$, and $r = y$. We may alſo, for greater ſimplicity, ſuppoſe the machine without inertia and friction. The velocity of p is now $\frac{pm^2 - rmn}{pm^2 + rn^2}$.

16 Abſolute meaſure of them.

Let g be the velocity which gravity generates in a ſecond. Then it will generate the velocity $g\dot{t}$ in the moment $\dot{t}$. Let $\dot{v}$ be the velocity generated during this moment in p, connected as it is with the wheel and axle, and with r. This connection produces a change of condition $= g\dot{t} - \dot{v}$. For, had it fallen freely, it would have acquired the velocity $g\dot{t}$, whereas it only acquires the velocity $\dot{v}$. In like manner, had r fallen freely, it would have acquired the velocity $g\dot{t}$. But, inſtead of this, it is raiſed with the velocity $\frac{n}{m}\dot{v}$. The change on it is therefore $= g\dot{t} + \frac{n}{m}\dot{v}$. Theſe changes of mechanical condition ariſe from their connection with the corporeal machine. Their preſſures on it bring into action its connecting forces, and each of the two external forces is in immediate equilibrium with the force exerted by the other. The force excited at the impelled point, by r acting at the working point, may be called the momentum or energy of r. Theſe energies are preciſely competent to the production of the changes which they really produce, and muſt therefore be conceived as having the ſame proportions. They are therefore equal and oppoſite, by the general laws *obſerved* in all actions of tangible matter; that is, they are ſuch as balance each other. Thus, and only thus, the remaining motions are what we obſerve them to be.

That is, $p \times \overline{g\dot{t} - \dot{v}} \times m = r \times \overline{g\dot{t} + \frac{n}{m}\dot{v}} \times n$

Or $pmg\dot{t} - pm\dot{v} = rng\dot{t} + r\frac{n^2}{m}\dot{v}$

Or $pm^2g\dot{t} - pm^2\dot{v} = rmng\dot{t} + rn^2\dot{v}$

Or $\overline{pm^2 - rmn} \times g\dot{t} = \overline{pm^2 + rn^2} \times \dot{v}$

That is, $pm^2 + rn^2 : pm^2 - rmn = g\dot{t} : \dot{v}$

That is, *the denominator of the fraction, expreſſing the velocity of the impelled point, is to the numerator as the velocity which a heavy body would acquire in the moment* $\dot{t}$, *by falling freely, is to the velocity which the impelled point acquires in that moment.* The ſame thing is true of the velocity of the working point.

This reaſoning ſuffers no change from the more complicated nature of the general propoſition. Here the impelling power is ſtill p, but the matter to be accelerated by it at the working point is $a + y$, while its reaction, diminiſhing the impelling power, is only r. We have only to conſider, in this caſe, the velocity with which $a + y$ would fall freely when impelled, not by $a + y$, but only by r. The reſult would be the ſame; $g\dot{t}$ would ſtill be to $\dot{v}$ as the denominator of the ſame fraction to its numerator.

Thus have we diſcovered the momentary acceleration of our machine. It is evident, that if the preſſures p and r, and the friction and inertia of the machine, and the external matter, continue the ſame, the acceleration will continue the ſame; the motion of rotation will be uniformly accelerated, and $pm^2 + \overline{a+y}n^2$ will be to $pm^2 - \overline{r+f}mn$ as the ſpace s, through which a heavy body would fall in any given time t, is to the ſpace through which the impelled point will really have moved in the ſame time. In like manner, the ſpace through which the working point moves in the ſame time is $= \frac{pmn - \overline{r+f}n^2}{pm^2 + \overline{a+y}n^2}s$.

Thus are the motions of the working machine determined. We may illuſtrate it by a very ſimple example. Suppoſe a weight p of five pounds, deſcending from a pulley, and dragging up another weight r of three pounds on the other ſide. m and n are equal, and each may be called 1. The formula becomes $\frac{p-r}{p+r}s$, or $\frac{5-3}{5+3}s$, or $\frac{2}{8} = \frac{1}{4}s$. Therefore, in a ſecond, the weight p will deſcend $\frac{1}{4}$th of 16 feet, or 4 feet; and will acquire the velocity of 8 feet per ſecond.

17 Performance of the machine.

Having obtained a knowledge of the velocity of every point of the machine, we can eaſily aſcertain its performance. This depends on a combination of the quantity of reſiſtance that is overcome at the working point, and the velocity with which it is overcome. Thus, in raiſing water, it depends on the quantity (proportional to the weight) of water in the bucket or pump, and the velocity with which it is lifted up. This will be had by multiplying the third formula by r, or by $rg\dot{t}$, or by rs. Therefore we obtain this expreſſion,

Work done $= \frac{pmrn - \overline{r+f}rn^2}{pm^2 + \overline{a+y}n^2}g\dot{t}$. (IV.)

Such is the general expreſſion of the momentary performance of the machine including every circumſtance which can affect it. But a variation of thoſe circumſtances produces great changes in the reſults. Theſe muſt be diſtinctly noticed.

Cor. 1. If $pmrn$ be equal to $\overline{r+f}rn^2$, there will be no work done, becauſe the numerator of the fraction is annihilated. There is then no unbalanced force, and the

the natural power is only able to balance the preffure propagated from the working point to the impelled point.

2 In like manner, if $n = o$, no work is done altho' the machine turns round. The working point has no motion. For the fame reafon, if m be infinitely great, although there is a great prevalence of impelling momentum, there will not be any fenfible performance during a finite time. For the velocity which p can imprefs is a finite quantity, and the impelled point cannot move fafter than x would be moved by it if detached from the machine. Now when the infinitely removed impelled point is moved through any finite fpace, the motion of the working point muft be infinitely lefs, or nothing, and no work can be done.

Remark. We fee that there are too values of n, viz. v, and $m \times \frac{p}{r}$, which give no performance. But in all other proportions of m and n fome work is done. Therefore, as we gradually vary the proportion of m to n, we obtain a feries of values expreffing the performance, which muft gradually increafe from nothing, and then decreafe to nothing. There muft therefore be fome proportion of m to n, depending on the proportion of p to $\overline{r+f}$, and of x to $\overline{a+y}$, which will give the greateft poffible value of the performance. And, on the other hand, if the proportion of m to n be already determined by the conftruction of the machine already erected, there muft be fome proportion of p to $\overline{r+f}$, and of x to $\overline{a+y}$, by which the greateft performance of the machine may be enfured. It is evident that the determination of thefe two proportions is of the utmoft importance to the improvement of machines. The well-informed reader will pardon us for endeavouring to make this appear more forcibly to thofe who are lefs inftructed, by means of fome very fimple examples of the firft principle.

Suppofe that we have a ftream of water affording three tons per minute, and that we want to drain a pit which receives one ton per minute, and that this is to be done by a wheel and axle? We wifh to know the beft proportion of their diameters m and n. Let m be taken $= 6$; and fuppofe,

1. That $n = 5$.
Then $\frac{pmrn - r^2n^2}{pm^2 + rn^2} = \frac{3.6.1.5 - 1.25}{3.36 + 1.36}, = \frac{65}{133}, = 0{,}4887$

2. Let n be $= 6$. The formula is $= 0{,}5$.

3. Let $n = 7$. The formula is $= 0{,}49045$. Hence we find, that the performance is greater when n is 6 than when it is either 5 or 7.

As an example of the fecond principle, fuppofe the machine a fimple pulley, and let p be 10.

1. Let r be $= 3$. The formula is $\frac{10 \times 3 - 9}{10 + 3} = \frac{21}{13}$, $= 1{,}6154$.

2. Let r be $= 4$. The formula is $= \frac{10 \times 4 - 16}{10 + 4}$, $= \frac{24}{14}, = 1{,}7143$.

3. Let r be $= 5$. The formula is $= \frac{10 \times 5 - 25}{10 + 5}$, $= \frac{25}{15}, = 1{,}6666$. Here it appears, that more work is done when r is 4 than when it is 5 or 3.

It muft therefore be allowed to be one of the moft important problems in practical mechanics to determine that conftruction by which a given power fhall overcome a given refiftance with the greateft advantage, and the proportion of work which fhould be given to a machine already contructed fo as to gain a fimilar end. 18

Proportion of the machine which gives the greateft work.

I. The general determination of the firft queftion has but little difficulty. We muft confider n as the variable magnitude in the formula $\frac{pmrn - \overline{r+f}\,rn^2}{pm^2 + \overline{a+y}\,n^2}$, which expreffes the work done; and find its value when the formula is a maximum. Taking this method, we fhall find that the formula IV. is a maximum when n is $= m\,\frac{\sqrt{x^2(r+f)^2 + p^2x(a+y)} - x(r+f)}{p(a+y)}$.

This expreffion of the performance, in its beft ftate, appears pretty complex; but it becomes much more fimple in all the particular applications of it, as the circumftances of the cafe occur in practice.

We have obtained a value of n expreffed in parts of m. If we fubftitute this for n in the third formula, we obtain the greateft velocity with which the refiftance r, connected with the inertia y, can be overcome by the power p, connected with the inertia x, by the intervention of a machine, whofe momentum of inertia and friction are an^2 and fn. This is $= \frac{r+f}{2\,\overline{a+y}} \times \left(\sqrt{\frac{p^2\,\overline{a+y}}{\overline{r+f}^2\,x} + 1} - 1\right) g\,t$. This expreffes the velocity of the working point in feet per fecond, and therefore the actual performance of the machine.

But the proper proportion of m to n, afcertained by this procefs, varies exceedingly, according to the nature both of the impelling power, and of the work to be performed by the machine.

1. It frequently happens that the work exerts no contrary ftrain on the machine, and confifts merely in impelling a body which refifts only by its inertia. This is the cafe in urging round a milftone or a heavy fly; in urging a body along a horizontal plane, &c. In this cafe r does not enter into the formula, which now becomes $m \times \frac{\sqrt{x^2f^2 + p^2x(a+y)} - xf}{p(a+y)}$. If the friction be infignificant, we may take $n = m\sqrt{\frac{p^2x(a+y)}{p^2(a+y)^2}}$ $= m\sqrt{\frac{x}{a+y}}$. The velocity of the working point is nearly $= \frac{p}{2\sqrt{x\,\overline{a+y}}}$. In this cafe, it will be found that the velocity acquired at the end of a given time will be nearly in the proportion of the power applied to the machine.

2. On the other hand, and more frequently, the inertia of the external matter which muft be moved in performing the work need not be regarded. Thus, in the grinding of grain, fawing of timber, boring of cylinders, &c. the quantity of motion communicated to the flour, to the faw-duft, &c. is too infignificant to be taken into the account. In this cafe, y vanifhes from the formula, which becomes extremely fimple when the friction and inertia of the machine are inconfiderable. We fhall

ſhall not be far from the truth if we make m to n as $2r$ to p, or $n = m \times \frac{p}{2r+f}$. In this caſe, the velocity of the working point is $\frac{p^2}{4x(r+f) + \frac{a p^2}{4(r+f)}}$

But it is rare that machines of this kind have a ſmall inertia. They are generally very ponderous and powerful; and the force which is neceſſary for generating even a very moderate motion in the unloaded machine (that is, unloaded with any work), bears a great proportion to the force neceſſary for overcoming the reſiſtance oppoſed by the work. The formula muſt therefore be uſed in all the terms, becauſe a is joined with y. It would have been ſimpler in this particular, had a been joined with x in the expreſſion of the angular velocity.

3. In ſome caſes we need not attend to the inertia of the power, as in the ſteam engine. In this caſe, if taken ſtrictly, n appears to have no value, becauſe x is a factor of every term of the numerator. But the formula gives this general indication, that the more inſignificant the inertia of the moving power is ſuppoſed, the larger ſhould m be in proportion to n; provided always, that the impelling power is not, by its nature, greatly diminiſhed, by giving ſo great a velocity to the impelled point. This circumſtance will be particularly conſidered afterwards.

4. If the inertia of the power and the reſiſtance be proportional to their preſſures, as when the impelling power is water lying in the buckets of an overſhot wheel, and the work is the raiſing of water, minerals, or other heavy body, acting *only* by its weight; then p and r may be ſubſtituted for x and y, and the formula expreſſing the value of n, when the performance is a maximum, becomes

$$n = m\,\frac{\sqrt{p^2 \times \overline{r+f}^2 + p^3 \times \overline{a+r}} - p \times \overline{r+f}}{p \times \overline{a+r}}$$

If, in this caſe, the inertia and friction of the machine may be diſregarded, as may often be done in pulleys, we have

$$n = m\sqrt{\frac{p}{r}+1} - 1.$$

If we make m the unit of the radii, and r the unit of force, we have

$$n = \sqrt{p+1} - 1, \text{ in parts of } m = 1.$$

Or, making $p = 1$, we have $n = \sqrt{\frac{1}{r}+1} - 1$.

Theſe very ſimple expreſſions are of conſiderable uſe, even in caſes where the inertia of the machine is very conſiderable, provided that it have no reciprocating motions. A ſimple wheel and axle, or a train of good wheelwork, have very moderate friction. The general reſults, therefore, which even very unlettered readers can deduce from theſe ſimple formulæ, will give notions that are uſeful in the caſes which they cannot ſo thoroughly comprehend. Some ſervice of this kind may be derived from the following little table of the beſt proportions of m to n, correſponding to the proportions of the power furniſhed to the engineer, and the reſiſtance which muſt be overcome by it. The quantity r is always $= 10$, and $m = 1$.

p	n	p	n
1	0,0488	10	0,4142
2	0,0954	20	0,7321
3	0,1402	30	1,
4	0,1832	40	1,2362
5	0,2246	50	1,4495
6	0,2649	60	1,6457
7	0,3038	70	1,8284
8	0,3416	80	2,
9	0,3784	90	2,1623
10	0,4142	100	2,3166

This muſt ſuffice for a very general view of the firſt problem.

II. The next queſtion is not leſs momentous, namely, to determine for a machine of a given conſtruction that proportion of the reſiſtance at the working point to the impelling power which will enſure the greateſt performance of the machine; that is, the proportion of m to n being given, to find the beſt proportion of p to r. 19 Beſt proportion of the power and work.

This is a much more complicated problem than the other; for here we have to attend to the variations both of the preſſures p and r, and alſo of the external matters x and y, which are generally connected with them. It will not be ſufficient therefore to treat the queſtion by the uſual fluxionary proceſs for determining the maximum, in which r is conſidered as the only varying quantity. We muſt, in this curſory diſcuſſion, reſt ſatisfied with a comprehenſion of the circumſtances which moſt generally prevail in practice.

It muſt either happen, that when r changes, there is no change (that is, of moment) in the maſs of external matter which muſt be moved in performing the work, or that there is alſo a change in this circumſtance. If no change happens, the denominator of the fourth formula, expreſſing the performance, remains the ſame; and then the formula attains a maximum when the numerator $p\,r\,m\,n - \overline{r+f}\,r\,n^2$ is a maximum. Alſo, we may include f without complicating the proceſs, by the conſideration, that f is always in nearly the ſame ratio to r; and therefore $r+f$ may be conſidered as a certain multiple of r, ſuch as $b\,r$. We may therefore omit f in the fluxionary equations for obtaining the maximum, and then, in computing the performance, divide the whole by b. Thus if the whole friction be $\frac{1}{20}$th of the reſiſting preſſure r, we have $r+f = \frac{21}{20}$ of r, and $b = \frac{21}{20}$. Having aſcertained the beſt value for r, we put this in its place in the fourth formula, and take $\frac{20}{21}$ of this for the performance. This will never differ much from the truth.

This proceſs gives us $p\,m\,n = 2\,n^2\,r$, and $r = \frac{p\,m\,n}{2\,n^2}$, $= \frac{p\,m}{2\,n}$; and if we farther ſimplify the proceſs, by making $p = 1$, and $m = 1$, we have $r = \frac{1}{2\,n}$; a moſt ſimple expreſſion, directing us to make the reſiſtance one half of what would balance the impelling power by the intervention of the machine.

This

This will evidently apply to many very important cafes, namely, to all thofe in which the matter put in motion by the working point is but trifling.

But it alfo happens in many important cafes, that the change is at leaft equally confiderable in the inertia of the work. In this cafe it is very difficult to obtain a general folution. But we can hardly imagine fuch a change, without fuppofing that the inertia of the work varies in the fame proportion as the preffure excited by it at the working point of the machine; for fince r continues the fame in kind, it can rarely change but by a proportional change of the matter with which it is connected. Yet fome very important cafes occur where this does not happen. Such is a machine which forces water along a long main pipe. The refiftance to motion and the quantity of water do not follow nearly the fame ratio. But in the cafes in which this ratio is obferved, we may reprefent y by any multiple $b\,r$ of r, which the cafe in hand gives us; b being a number, integer, or fractional. In the farther treatment of this cafe, we think it more convenient to free r from all other combinations; and inftead of fuppofing the force f (which we made equivalent with the friction of the machine) to be applied at the working point, we may apply it at the impelled point, making the effective power $q=p-f$. For the fame reafons, inftead of making the momentum of the machine's inertia $= a\,n^2$, we may make it $a\,m^2$, and make $a+x=z$. Now, fuppofing q, or $p-f$, $=1$, and alfo $m=1$, our formula expreffing the performance becomes $\frac{r\,n - r^2 n^2}{z + b\,r\,n^2}$. This is a maximum when $r = \frac{\sqrt{z^2 + z\,b\,n} - z}{b\,n^2}$.

Cor. 1. If the inertia of the work is always equal to its preffure, as when the work confifts wholly in raifing a weight, fuch as drawing water, &c. then $b=1$, and the formula for the maximum performance becomes $r = \frac{\sqrt{z\,n + z^2} - z}{n^2}$.

2. If the inertia of the impelling power is alfo the fame with its preffure, and if we may neglect the inertia and friction of the machine, the formula becomes $r = \frac{\sqrt{n+1} - 1}{n^2}$.

Example. Let the machine be a common pulley, fo that the radii m and n are equal, and therefore $n=1$. Then, $r = \frac{\sqrt{1+1} - 1}{1}$, $= \sqrt{2} - 1$, $= 0{,}4142$, &c. more than $\frac{2}{5}$ths of what would balance it.

Here follows a feries of the beft values of r, correfponding to different values of n. m and p are each $=1$. The numbers in the laft column have the fame proportion to 1 which r has to the refiftance which will balance p.

n	r	
$n = \frac{1}{4}$	$r =$ 1,8885	0,4724 to 1
$\frac{1}{3}$	1,3928	0,4639
$\frac{1}{2}$	0,8986	0,4493
1	0,4142	0,4142
2	0,1830	0,3660
3	0,1111	0,3333
4	0,0772	0,3088

From what has now been eftablifhed, we fee with fufficient evidence the importance of the higher mathematics to the fcience of mechanics. If the velocities of the impelled and working points of an engine are not properly adjufted to the preffures, the inertia, and the friction of the machine, we do not derive all the advantages which we might from our fituation. Hence alfo we learn the falfity of the maxim which has been received as well founded, that the augmentation of intenfity of any force, by applying it to the long arm of a lever, is always fully compenfated by a lofs of time; or, as it is ufually expreffed, "what we gain by a machine in force we lofe in time." If the proportion of m to n is well chofen, we fhall find that the work done, when it refifts by its inertia only, increafes nearly in the proportion of the power employed; whereas, when the inertia of the work is but a fmall part of the refiftance, it increafes nearly in the duplicate ratio of the power employed.

General but erroneous maxim.

It was remarked in the fetting out in the prefent problem, that the formulæ do not immediately exprefs the velocity of any point of the machine, but its momentary acceleration. But this is enough for our purpofe; becaufe, when the momentary acceleration is a maximum, the velocity acquired, and the fpace defcribed, in any given time, is alfo a maximum. We alfo fhewed how the real velocities, and the fpaces defcribed, may be afcertained in known meafures. We may fay in general, that if g reprefent the preffure of gravity on any mafs of matter w, then $\frac{g}{w}$ is to $\frac{p\,m\,n - \overline{r+f}\,n}{a\,m^2 + \overline{a+y}\,n^2}$ as 16 feet to the fpace defcribed in a fecond by the working point in a fecond, or as 32 feet per fecond is to the velocity acquired in that time.

20 Caufe why machines do not continually accelerate.

A remark now remains to be made, which is of the greateft confequence, and gives an unexpected turn to the whole of the preceding doctrines. It appears, from all that has been faid, that the motion of a machine muft be uniformly accelerated, and that any point will defcribe fpaces proportional to the fquares of the times; for while the preffures, friction, and momentum of inertia remain the fame, the momentary acceleration muft alfo be invariable. But this feems contrary to all experience. Such machines as are properly conftructed, and work without jolts, are obferved to quicken their pace for a few feconds after ftarting; but all of them, in a very moderate time, acquire a motion that is fenfibly uniform. Is our theory erroneous, or what are the circumftances which remain to be confidered, in order to make it agree with obfervation? The fcience of machines is imperfect, till we have explained the caufes of this deviation from the theory of uniform acceleration.

Thefe caufes are various.

1. Increafe of friction.

1. In fome cafes, every increafe of velocity of the machine produces an increafe of friction in all its communicating parts. By thefe means, the accelerating force, which is $p\,m - \overline{r+f}\,n$, or $\overline{p-f}\,m - r\,n$, is diminifhed, and confequently the acceleration is diminifhed. But it feldom happens that friction takes away or employs the whole accelerating force. We are not yet well inftructed in the nature of friction. Moft of the kinds of friction which obtain in the communicating parts of machines, are fuch as do not fenfibly increafe by an increafe of velocity; fome of them really diminifh. Yet even the moft accurately conftructed machines, unloaded with work, attain a motion that is fenfibly uniform. If we take off the pallets from a pendulum

dulum clock, and allow it to run down amain, it accelerates for a while, but in a very moderate time it acquires an uniform motion. So does a common kitchen jack. Thefe two machines feem to bid the faireft of any for an uniformly accelerated motion; for their impelling power acts with the utmoft uniformity. There is fomething yet unexplained in the nature of friction, which takes away fome of this acceleration.

. Refiftance of air. But the chief caufe of its ceffation in thefe two inftances, and others *of very rapid motion*, is the refiftance of the air. This arifes from the motion which is communicated to the air difplaced by the fwift moving parts of the machine. At firft it is very fmall; but it increafes nearly in the duplicate ratio of the velocity (fee *Resistance of Fluids*, Encycl.) Thus r increafes continually; and, in a certain ftate of motion, $\overline{r + f n}$ becomes equal to $p\ m$. Whenever this happens, the accelerating power is at an end. The acceleration alfo ceafes; and the machine is in a ftate of dynamical equilibrium; not at reft, but moving uniformly, and performing work.

. Increafe of refiftance very imperfectly known. Still, however, this is not one of the general caufes of the uniform motion attained by working engines. Rarely is the motion of their parts fo rapid, as to occafion any great refiftance from the air. But in the moft frequent employments of machines, every increafe of velocity is accompanied by an increafe of refiftance from the work performed. This occurs at once to the imagination; and few perfons think of inquiring farther for a reafon. But there is perhaps no part of mechanics that is more imperfectly underftood, even in our prefent improved ftate of mechanical fcience. In many kinds of work, it is very difficult to ftate what increafe of labour is required in order to perform the work with twice or thrice the fpeed. In grinding corn, for inftance, we are almoft entirely ignorant of this matter. It is very certain, that twice the force is not neceffary for making the mill grind twice as faft, nor even for making it grind twice as much grain equally well. It is not eafy to bring this operation under mathematical treatment; but we have confidered it with fome attention, and we imagine that a very great improvement may ftill be made in the conftruction of grift mills, founded on the law of variation of the refiftance to the operation of grinding, and a fcientific adjuftment of m to n, in confequence of our knowledge of this law. We may make a fimilar obfervation on many other kinds of work performed by machines. In none of thofe works where the inertia of the work is inconfiderable, are we well acquainted with the real mechanical procefs in performing it. This is the cafe in fawing mills, boring mills, rolling mills, flitting mills, and many others, where the work confifts in overcoming the ftrong cohefion of a fmall quantity of matter. In fawing timber (which is the moft eafily underftood of all thefe operations), if the faw move with a double velocity, it is very difficult to fay how much the actual refifting preffure on the teeth of the faw is increafed. Twice the number of fibres are neceffarily torn afunder during the fame time, becaufe the fame number are torn by one defcent of the faw, and it makes that ftroke in half the time. But it is very uncertain whether the refiftance is double on this account; becaufe if each fibre be fuppofed to have the fame tenacity in both cafes, it refifts with this tenacity only for half the time. The parts of bodies refift a fimilar change of condition in different manners; and there is another difference in their refiftance of different changes—the refiftance of red hot iron under the roller may vary at a very different rate from that of its refiftance to the cutting tool. The refiftance of the fpindles of a cotton mill, arifing partly from friction, partly from the inertia of the heaped bobbins, and partly from the refiftance of the air, is ftill more complicated, and it may be difficult to learn its law. The only cafe in which we can judge with fome precifion is, when the inertia of matter, or a conftant preffure like that of gravity, conftitutes the chief refiftance. Thus in a mill employed to raife water by a chain of buckets, the refiftance proceeds from the inertia only of the water. The buckets are moving with a certain velocity, and the loweft of them takes hold of a quantity of water lying at reft in the pit, and drags it into motion with its acquired velocity. The force required for generating this motion on the quiefcent water muft be double or triple, when the velocity that muft be given to it is fo. This abforbs the overplus of the impelling power, by which that power exceeds what is neceffary for balancing the weight of the water contained in all the afcending buckets. This is a certain determinate quantity which does not change; for in the fame inftant that a new bucket of water is forced into motion below, and its weight added to that of the afcending buckets, an equal bucket is emptied of its water at top. The afcending buckets require only to be balanced, and they then *continue* to afcend, with any velocity already acquired. While the machine moves flow, the motion impreffed on the new bucket of water is not fufficient to abforb all the overplus of impelling power. The quantity not abforbed accelerates the machine, and the next bucket muft produce more motion in the water which it takes up. This confumes more of the overplus. This goes on till no overplus of power is left, and the machine accelerates no more. The complete performance of the machine now is, that "a certain quantity of water, formerly at reft, is now moving with a certain velocity." Our engineers confider it differently; "as a certain *weight* of water lifted up." But while the machine is thus moving uniformly, it is really not doing fo much as before; that is, it is not exerting fuch great preffures as before the motion was rendered uniform: for at that time there was a preffure at the working point equal to the weight of all the water in the afcending buckets; and alfo an overplus of preffure, by which the whole was accelerated. In the ftate of uniform motion, the preffure is no more than juft balances the weight of the afcending chain. We fhall learn by and bye how the preffures have been diminifhing, although the mill has been accelerating; a thing that feems a paradox.

In this inftance, then, we fee clearly, why a machine muft attain a uniform motion. A pumping machine gives us the fame opportunity, but in a manner fo different as to require explanation. The pifton may be fuppofed at the very furface of the pit water, and the impelling power may be lefs than will fupport a column in the pipe as high as can be raifed by the preffure of the atmofphere. Suppofe the impelling power to be the water lying in the buckets of an overfhot wheel. Let

Let this water be laid into the buckets by a very fmall ftream. It will fill the buckets very flowly; and as this gives them a preponderance, the mill lofes its balance, the wheel begins to move, and the pifton to rife, and the water to follow it. The water may be delivered on the wheel drop by drop; the pifton will rife by infenfible degrees, always ftanding ftill again as foon as the atmofpheric preffure on it juft balances the water on the wheel. The water in the rifing pipe is always a balance to the preffure of the atmofphere on the ciftern; therefore the preffure of the atmofphere on the pifton (which is the r in our formula) is equal to the weight of this water. Our pump-makers therefore (calling themfelves engineers) fay, that the weight of water in the pipe balances the water on the wheel. It does not balance it, nor is it raifed by the wheel, but by the atmofphere; but it ferves us at prefent for a meafure of the power of the wheel. At laft, all the buckets of the wheel are full, and the water is (for example) 25 feet high in the pipe. Now let the ftream of water run its full quantity. It will only run over from bucket to bucket, and run off at the bottom of the wheel; but the mill will not move, and no work will be performed. (N. B. We are here excluding all impulfe or ftroke on the buckets, and fuppofing the water to act only by its weight.) But now let all be emptied again, and let the water be delivered on the wheel in its full quantity as at the firft. The wheel will immediately acquire a preponderancy, which will *greatly* exceed the firft fmall preffure of the atmofphere on the pifton. It will therefore accelerate the pifton, overcoming the preffure of the air with great velocity. The pifton rifes faft; the water follows it, by the preffure of the atmofphere; and when it attains the former utmoft height, it attains it with a confiderable velocity. If allowed to run off there, it will *continue* to run off with that velocity; becaufe there is the fame quantity of water preffing round the wheel as before, and therefore enough to balance the preffure of the atmofphere on the pifton. The preffure of the fame atmofphere on the water in the ciftern, raifed the water in the pipe with this velocity; therefore it will continue to do fo, and the mill will deliver water by the pump with this velocity, although there is no more preffure acting on it than before, when the water ran to wafte, doing no work whatever.

This mode of action is extremely different from the former example. The mill is not acting againft the inertia y of the water to be moved, but againft the preffure r of the atmofphere on the pifton. The preffure of the fame atmofphere on the ciftern is employed againft the inertia of the water in the pipe; and the ufe of the mill is to *give occafion*, by raifing the pifton, to the exertion of this atmofpherical preffure, which is the real raifer of the water. The maxim of conftruction, and the proper adjuftment of m to n in this cafe, are different from the former; and we fhould run the rifk of making an imperfect engine were we to confound them.

We muft mention another cafe of a pumping mill, feemingly the fame with this, but effentially different. Suppofe the pipe of this pump to reach 30 feet below the furface of the pit water, and that the pifton is at the very bottom of it. Suppofe alfo, that the wheel buckets, when filled with water, only enable it to *fupport* 25 feet of water in the rifing pipe. Let the water be delivered into the wheel drop by drop. The wheel will gradually preponderate; the pifton will gradually rife, lifting the water above it, fuftaining a preffure of water which gradually increafes. At laft, the water in the pump is 25 feet higher than that in the ciftern; the wheel is full and running to wafte; but no work is performed. Let all be emptied, and now let the water come to the wheel in its full ftream, but without impulfe. The pifton will lift the water brifkly, bring it to 25 feet high with a confiderable velocity, and the mill will now raife it with this velocity. In this example the mill is the immediate agent in raifing the water; but, in this cafe alfo, its ultimate office is not overcoming inertia, but overcoming preffure. It was the overplus of power only that was employed in overcoming inertia, while accelerating the water in the rifing pipe, in order to give it the neceffary velocity for a continued difcharge.

These and fimilar examples fhew the great difference between the ftatical and dynamical equilibrium of machines, and the neceffity of a fcientific attention by all who wifh to improve practical mechanics. Without this, and even a pretty refined attention, we cannot fee the connection between a copious fupply of water to the bucket wheel and a plentiful difcharge by the pump. We believe, that the greateft part of thofe employed in erecting machines conceive it as owing to the greater weight of water impelling the wheel with greater force; but we fee that there is no difference in the preffures on the mill at reft, and the mill doing its work fteadily and uniformly, with any velocity, however great. Without keeping the notions of that part of the impelling power which fupports diftinct from that of the part which accelerates, we fhall never have a clear conception of the operation of machines, or of mechanical power in general. We cannot derive all the advantages of our natural powers, without knowing how our machine employs the preffure excited by it at the working point; that is, without perceiving in what cafes it is oppofed to inertia, and in what to the mechanical properties of tangible matter. This only can inform us at what rate the refiftance varies by a change of velocity; and when it happens that this augmentation, neceffarily accompanied by an augmentation of all the frictions, and the refiftance of the air, is in equilibrio with the whole of the impelling power, and all acceleration is at an end. 21

The chief caufe is a real diminution of power.

Laftly, another chief caufe of the finally uniform motion of machines is, that, in moft cafes, an increafe of velocity produces a real diminution of impelling power. We hardly know any exception to this befides the employment of *one* defcending weight as a power or firft mover. Moft of the powers which we employ refide in bodies external to the machine; and thefe bodies muft be put in motion, and continued in that motion, in order to continue their preffure on the impelled point. Frequently a great part of the power is employed in giving this neceffary motion to the external matter, and the remainder only is employed in preffing forward the machine. We mentioned a remarkable inftance of this in the operation of thrafhing. Now, the power thus employed muft increafe in proportion to the motion required; that is, in proportion to the velocity of the impelled 22 pelled point; what remains, urging forward the machine, is therefore diminifhed. The acceleration is therefore diminifhed, and may ceafe. At *laft* the actual preffure is fo much diminifhed, that it is no more than what is neceffary for overcoming the increafed refiftance of the work, the increafed friction. The machine therefore accelerates no more, but moves uniformly.

[T]his caufe [v]ery gene[r]al.

This caufe of the diminution of power by an increafe of velocity, obtains in all cafes where the ftrength of animals, of fprings, the force of fired gunpowder, &c. is exerted. In fome cafes, the vifible effect is not very confiderable; as in the employment of a ftrong fpring, the force of gunpowder, and a few others. In the action of animals, this defalcation of power is very great when the velocity is confiderable. Nay, even in the action of gravity, although it acts as ftrongly on a body in rapid motion as on one at reft, yet when gravity is not the immediate agent, but acts by the intervention of a body in which it refides, the neceffity of previoufly moving this body frequently diminifhes the acceleration which it would otherwife produce. Thus, in an overfhot wheel, if the water be delivered into the bucket with a velocity (eftimated in the direction of the part of the wheel, into which it is delivered) lefs than that of the rim of the wheel, it muft retard the motion; for it muft be immediately dragged into that motion; that is, part of the accelerating overplus, already acting on the wheel, muft be employed in accelerating this new bucket of water, and this muft leffen the general acceleration of the machine. Hence we learn, that the water muft be delivered on the wheel with a velocity that is at leaft not lefs than that of the wheel's motion.

[I]t obtains [i]n all machines actuated by impulfion,

The cafe in which we fee this diminution of power on machines moft diftinctly is, when water or wind, acting by impulfe alone, is our moving power. Since the mutual impulfes of bodies depend entirely on their relative motions (fee Impulsion, *Suppl.*), it follows, that when the velocity of the impelled point is augmented, the impulfion, or effective preffure, muft be diminifhed. Nay, this velocity may be fo increafed, that there fhall be no relative motion, and therefore no impulfion. If the floats of an underfhot wheel be moving with the velocity of the ftream, they remain conjoined in their progrefs, but without any mutual action. Therefore, when an underfhot wheel is fet into a running water, the firft impulfions are ftrong, and accelerate the wheel. This diminifhes the next impulfion and acceleration: but the wheel is ftill impelled and accelerated; lefs and lefs in every fucceeding moment, as it moves fafter; by and bye, the acceleration becomes infenfible, and the wheel appears to attain a motion which is perfectly uniform. This requires a very long time, or rather it is never attained, and we only cannot difcern the very fmall additions which are ftill made to the velocity. All this happens generally after a very moderate time, by reafon of various other obftructions.

[o]r by the [fo]rce of ani[m]als.

Animal action is fubject to the fame variation. We know, that there is a certain rate at which a horfe can run, exhaufting or employing his whole ftrength. If he be made to drag any the fmalleft load after him, he muft employ part of his force on it, and his fpeed will be checked. The more he is loaded with a draught, the flower he will run, ftill employing all his ftrength. The draught may be increafed till he is reduced to a trot, to a walk, nay, till he is unable to draw it. Now, juft inverting this procefs, we fee, that there is a certain ftrain which will fufficiently tire the horfe without ftirring from the fpot, but which he could continue to exert for hours. This is greater than the load that he can juft crawl along with, employing his ftrength as much as would be prudent to continue from day to day. And, in like manner, every leffer draught has a correfponding rate at which the horfe, employing his whole working ftrength, can continue to draw at during the working hours of a day. At fetting out, he pulls harder, and accelerates it. Following his pull, he walks fafter, and therefore pulls lefs (becaufe we are ftill fuppofing him to employ his whole working ftrength). At laft he attains that fpeed which occupies his whole ftrength in merely continuing the pull. Other animals act in a fimilar manner; and it becomes a general rule, that the preffure actually exerted on the impelled point of a machine diminifhes as its velocity increafes.

23
We muft diftinguifh between the power expended and the power employed.

From the concurrence of fo many facts, we perceive that we muft be careful to diftinguifh between the quantity of power expended, and the quantity that is ufefully employed, which muft be meafured folely by the preffure exerted on the machine. When a weight of five pounds is employed to drag up a weight of three pounds by means of a thread over a pulley, it defcends, with a motion uniformly accelerated, four feet in the firft fecond. Mr Smeaton would call this an expenditure of a mechanical power 20. The weight three pounds is raifed four feet. Mr Smeaton would call this a mechanical effect 12. Therefore the effect produced is not adequate to the power expended. But the fact is, that the preffure, ftrain, or mechanical power really exerted in this experiment, is neither five nor three pounds; the five pound weight would have fallen 16 feet, but it falls only 4. A force has therefore acted on it fufficient to make it defcribe 12 feet in a fecond, with a uniformly accelerated motion; for it has counteracted fo much of its weight. The thread was ftrained with a force equal to $3\frac{3}{4}$ pounds, or $\frac{3}{4}$ths of 5 pounds. In like manner, the three pound weight would have fallen 16 feet; but it was raifed 4 feet. Here was a change precifely equal to the other. A force of $3\frac{3}{4}$ pounds, acting on a mafs whofe matter is only 3, will, in a fecond, caufe it to defcribe 20 feet with a uniformly accelerated motion. Now, 5×12, and 3×20, give the fame product 60. And thus we fee, that the quantity of motion extinguifhed or produced, and not the product of the weight and height, is the true unequivocal meafure of mechanical power really expended, or the mechanical effect really produced; and that thefe two are always equal and oppofite. At the fame time, Mr Smeaton's theorem merits the attention of engineers; becaufe it generally meafures the opportunities that we have for procuring the exertion of power. In fome fenfe Mr Smeaton may fay, that the quantity of water multiplied by the height from which it defcends in working other machines, is the meafure of the power expended; becaufe we muft raife this quantity to the dam again, in order to have the fame ufe of it. It is expended, but not employed; for the water, at leaving the wheel, is ftill able to do fomething.

It requires but little confideration to be fenfible, that 24.

the preceding account of the ceffation of accelerated motion in our principal machines, muft introduce different maxims of conftruction from thofe which were exprefsly adapted to this acceleration; or rather, which proceeded on the erroneous fuppofition of the conftancy of the impelling power and the refiftance. The examination of this point has brought into view the fundamental principle of working machines, namely, the perfect equilibrium which takes place between the impelling power and the fimultaneous refiftance. It may be expreffed thus:

First principle of working machines.

The force required for preferving a machine in uniform motion, with any velocity whatever, is that which is neceffary for balancing the refiftance then actually exerted on the working point of the machine. We faw this diftinctly in the inftance of the two weights acting againft each other by the intervention of a thread over a fixed pulley. It is equally true of every cafe of acting machinery: for if the force at the impelled point be greater than what balances the refiftance acting at the fame point, it muft accelerate that point, and therefore accelerate the whole machine; and if the impelling force be lefs than this, the machine muft immediately retard in is motion. When the machine has once acquired this degree of motion, every part of it will continue in its prefent ftate of motion, if only the two external forces are in equilibrio, but not otherwife. But when the preffure of the external power on the impelled point balances the refiftance oppofed by that point, it is, in fact, maintaining the equilibrium with the external power acting at the working point; for this is the only way that external forces can be fet in oppofition to each other by the intervention of a body. The external forces are not in immediate equilibrio with each other, but each is in equilibrio with the force exerted by the point on which it acts. This force exerted by the point is a modification of the connecting forces of the body, all of which are brought into action by means of the actions of the external forces, and each is accompanied by a force precifely equal and oppofite to it. Now, the principles of ftatics teach us the proportions of the external preffures which are thus fet in equilibrium by the intervention of a body; and therefore teach us what proportion of power and refiftance will keep a machine of a given conftruction in a ftate of uniform motion.

This propofition appears paradoxical, and contrary to common obfervation; for we find, that, in order to make a mill go fafter, we muft either diminifh the refiftance, or we muft employ more men, or more water, or water moving with greater velocity, &c. But this arifes from fome of the caufes already mentioned. Either the refiftance of the work is greater when the machine is made to move fafter, or the impulfion of the power is diminifhed, or both thefe changes obtain. Friction and refiftance of air alfo come in for their fhare, &c. The actual preffure of a given quantity of the external power is diminifhed, and therefore more of it muft be employed. When a weight is *uniformly* raifed by a machine, the preffure exerted on it by the working point is precifely equal to its weight, whatever be the velocity with which it rifes. But, even in this fimpleft cafe, more natural power muft be expended in order to raife it fafter; becaufe either more natural power muft be employed to accelerate the external matter which is to prefs forward the impelled point, or the relative motion of the preffing matter will be diminifhed.

It is well known, that, in the employment of the mechanic powers, whether in their ftate of greateft fimplicity, or any how combined in a complicated machine, if the machine be put in motion, the velocities of the extreme points (which we have called the *impelled* and *working* points) are inverfely proportional to the forces which are in equilibrio when applied to thefe points in the direction of their motion. This is an inductive propofition, and has been ufed as the foundation of fyftems of mechanics. It is unneceffary to take up time in proving what is fo familiarly known; confequently, the products of the preffures at thofe points by the velocities of the motions are equal; that is, the product of the preffure actually exerted at the impelled point of a machine working uniformly, multiplied by the velocity of that point, is equal to the product of the refiftance actually exerted at the working point, multiplied by the velocity of that point, that is, by the velocity with which the refiftance is overcome,

$$p\,m = r\,n.$$

Now, the product of the refiftance, by the velocity with which it is overcome, is evidently the meafure of the performance of the machine, or the work done. The product of the actual preffure on the impelled point, by the velocity of that point, may be called the MOMENTUM OF IMPULSE.

Hence we deduce this propofition: 25

Second principle. Momentum of impulse and the performance of the machine are equal.

In all working machines which have acquired a uniform motion, the performance of the machine is equal to the momentum of impulfe (A).

This

(A) The truth of this propofition has been long perceived in every particular inftance that happened to engage the attention; but we do not recollect any mechanician before Mr Euler confidering it as a general truth, expreffing in a few words a mechanical law. This celebrated mathematician undertook, about the year 1735 or 1736, a general and fyftematic view of machines, in order to found a complete theory immediately conducive to the improvement of practical mechanics. In 1743 he publifhed the firft propofitions of this ufeful theory in the 10th volume of the *Comment. Petropolitani*, containing the excellent dynamical theorems of which we have given the fubftance. In the 3d volume of the *Comment. Novi Petropol.* he profecuted the fubject a little farther; and in the 8th volume, he entered on what we are now engaged in, and formally announces this fundamental propofition, calling thefe two products the *momentum of impulfe*, and the *momentum of effect*. It is much to be regretted, that this confummate mathematician did not continue thefe ufeful labours; his ardent mind being carried away by more abftrufe fpeculations in all the moft refined departments of mathematics and philofophy. No man in Europe could have profecuted the fubject with more judgment and fuccefs.—See alfo *Mem. Acad. Berlin*, 1747 and 1752.

This is a propoſition of the utmoſt importance in the ſcience of machines, and leads to the fundamental maxim of their conſtruction. Since the performance of a machine is equal to the momentum of impulſe, it increaſes and diminiſhes along with it, and is a maximum when the momentum of impulſe is a maximum; therefore the fundamental maxim in the conſtruction of a machine is to faſhion it in ſuch a manner, that the momentum of impulſe ſhall be a maximum, or that the product of the preſſure actually exerted on the impelled point of the machine by the velocity with which it moves may be as great as poſſible. Then are we certain that the product of the reſiſtance, by the velocity of the working point, is as great as poſſible, provided that we take care that none of the impulſe be needleſsly waſted by the way by injudicious communications of motion, by friction, by unbalanced loads, and by reciprocal motions, which irrecoverably waſte the impelling power. This maxim holds good, whether the reſiſtance remains conſtantly the ſame, or varies by any law whatever.

26 Important deſiderata for practice.

But much remains to be done for the improvement of mechanical ſcience before we can avail ourſelves of this maxim, and apply it with ſucceſs. The chief thing, and to this we ſhould give the moſt unremitting attention, is, to learn the changes which obtain in the actual preſſure exerted by thoſe natural powers which we can command; the changes of actual preſſure produced by a change of the velocity of the impelled point of the machine. Theſe depend on the ſpecific natures of thoſe powers, and are different in almoſt every different caſe. Nothing will more contribute to the improvement of practical mechanics than a ſeries of experiments, well contrived, and accurately made, for diſcovering thoſe laws of variation, in the caſes of thoſe powers which are moſt frequently employed. Such experiments, however, would be coſtly, beyond the abilities of an individual; therefore, it were greatly to be wiſhed that public aid were given to ſome perſons of ſkill in the ſcience to inſtitute a regular train of experiments of this kind. An experimental machine might be conſtructed, to be wrought either by men or by cattle. This ſhould be loaded wirh ſome kind of work which can be very accurately meaſured, and the load varied at pleaſure. When loaded to a certain degree, the men or cattle ſhould be made to work at the rate which they can continue from day to day. The number of turns made in an hour, multiplied by the load, will give the performance correſponding to the velocities; and thus will be diſcovered the moſt advantageous rate of motion. The ſame machine ſhould alſo be fitted for grinding, for ſawing, boring, &c. and ſimilar experiments will diſcover the relation between the velocities with which theſe operations are performed, and the reſiſtances which they exert. The laws of friction may be inveſtigated by the ſame machine. It ſhould alſo be fitted with a walking wheel, and the trial ſhould be made of the ſlope and the velocity of walking which gives the greateſt momentum of impulſe. It is not unreaſonable to expect great advantages from ſuch a train of experiments.

27 A ſubſtitute for them.

Till this be done, we muſt content ourſelves with eſtabliſhing the above, in the moſt general terms, applicable to any caſe in which the law of the variation of force may hereafter be diſcovered.

There is a certain velocity of the impelled point of a machine which puts an end to the action of the moving power. Thus, if the floats of an underſhot wheel be moving with the velocity of the ſtream, no impulſe is made on them. If the arm of a gin or capſtan be moving with that velocity with which a horſe or a man can juſt move, ſo as to continue at that ſpeed from day to day, employing all his working ſtrength, but not fatiguing himſelf; in this ſtate of motion, the animal can exert no preſſure on the machine. This may be called the EXTINGUISHING VELOCITY, and we may expreſs it by the ſymbol e. Let f be that degree of force or preſſure which the animal can exert at a dead pull or thruſt, as it is called. We do not mean the utmoſt ſtrain of which the animal is capable, but that which it can continue unremittingly during the working hours of a day, fully employing but not fatiguing itſelf. And let p be the preſſure which it actually exerts on the impelled point of a machine, moving with the velocity m. Let $e - m$ be called the RELATIVE VELOCITY, and let it be expreſſed by v. And let it be ſuppoſed that it has been diſcovered, by any means whatever, that the actual preſſure varies in the proportion of v^q, or $\overline{e-m}^q$. This ſuppoſition gives us $e^q : v^q = f : p$, and $p = f \times \frac{v^q}{e^q}$. For the machine muſt be at reſt, in order that the agent may be able to exert the force f on its impelled point. But when the machine is at reſt, what we have named the relative velocity is e, the whole of the extinguiſhing velocity.

The momentum of impulſe is $p\,m$, that is $\frac{v^q}{e^q} f m$, or $f \times \frac{v^q}{e^q} \times \overline{e-v}$ (becauſe $m = e - v$). Therefore $f \times \frac{v^q}{e^q} \times \overline{e-v}$ muſt be made a maximum. But f and e^q are two quantities which ſuffer no change. Therefore the momentum of impulſe will be a maximum when $v^q \times \overline{e-v}$ is a maximum. Now $v^q \times \overline{e-v} = v^q e - v^q v, = v^q e - v^{q+1}$. The fluxion of this is $q e v^{q-1} \dot{v} - \overline{q+1}\, v^q \dot{v}$. This being ſuppoſed $= o$, we have the equation

$$q e v^{q-1} = \overline{q+1}\, v^q$$

$$\text{And } q e = \overline{q+1}\, v$$

$$\text{Therefore } v = \frac{q e}{q+1}$$

And m, which is $= e - v$, becomes $\frac{e}{q+1}$. Therefore we muſt order matters ſo, that the velocity of the impelled point of the machine may be $= \frac{e}{q+1}$. Now p is $= f \frac{v^q}{e^q}$, and therefore $= f \times \frac{q^q}{\overline{q+1}^q}$. And $p\,m$, $= f \frac{q^q}{\overline{q+1}^q} m, = f \frac{q^q}{\overline{q+1}^q} \times \frac{e}{q+1} = f \times \frac{q^q e}{\overline{q+1}^{q+1}}$, $=$ the momentum of impulſe, and therefore $=$ the momentum of effect, or the performance of the machine, when in its beſt ſtate.

28 Example in underſhot mills by Mr Parent.

Thus may the maxim of conſtruction be ſaid to be brought to a ſtate of great ſimplicity, and of moſt eaſy recollection. A particular caſe of this maxim has been long known, having been pointed out by Mr Parent. Since the action of bodies depends on their relative velocity,

locity, the impulfe of fluids muft be as the fquare of the relative velocity. From which Mr Parent deduced, that the moft advantageous velocity of the floats of an underfhot wheel is one-third of that of the ftream. This maxim is evidently included in our general propofition; for in this cafe, the index q of that function of the relative velocity v, which is proportional to the impulfe, is $= 2$. Therefore we have the maximum when $v = \frac{2e}{2+1}, = \frac{2}{3}e$, and $m = \frac{1}{3}e$. e, the extinguifhing velocity, is evidently the velocity of the ftream. Our propofition alfo gives us the precife value of the performance. The impulfe of the ftream on the float at reft being fuppofed $= f$, its impulfe on the float moving with the velocity $\frac{2}{3}e$ muft be $= \frac{4}{9}f$. This is the meafure of the actual preffure p. This being multiplied by m, or by $\frac{1}{3}e$, gives $\frac{4}{27}f$. Now f is confidered as equal to the weight of a column of water, having the furface of the floatboard for its bafe, and the depth of the fluice under the furface of the refervoir (or, more accurately, the fall required for generating the velocity of the ftream) for its height. Hence it has been concluded, that the utmoft performance of an underfhot wheel is to raife $\frac{4}{27}$ of the water which impels it, to the height from which it falls. But this is not found very agreeable to obfervation. Friction, and many imperfections of execution in the delivery of the water, the direction of its impulfe, &c. may be expected to make a defalcation from this theoretical performance. But the actual performance, even of mills of acknowledged imperfection, confiderably exceeds this, and fometimes is found nearly double of this quantity. The truth is, that the particular fact from which Mr Parent firft deduced this maxim (namely, the performance of what is called *Parent's* or *Dr Barker's mill*), is, perhaps of all that could have been felected, the leaft calculated for being the foundation of a general rule, being of a nature fo abftrufe, that the firft mathematicians of Europe are to this day doubtful whether they have a juft conception of its principles. Mr Smeaton's experiments fhew very diftinctly, that the maximum of performance of an underfhot wheel correfponds to a velocity confiderably greater than one-third of the ftream, and approaches nearly to one-half; and he affigns fome reafons for this which feem well founded. But, independent of this, the performance of Mr Smeaton's model was much greater than what correfponds with the velocity by the above mentioned eftimation of f. The theory of the impulfion of fluids is extremely imperfect; and Daniel Bernoulli fhews, from very unqueftionable principles, that the impulfe of a narrow vein of fluid on an extended furface is double of what was generally fuppofed; and his conclufions are abundantly confirmed by the experiments adduced by him.

Not accurate.

29

This fubftitute is ufeful even where it is not altogether exact.

It is by no means pretended that the maxim of conftruction is reduced to the great fimplicity enounced in the propofition now under confideration. We only fuppofed that a cafe had been obferved where the preffure exerted by fome natural agent did follow the proportions of v^q. This being admitted, the propofition is ftrictly true. But we do not know any fuch cafe; yet is the propofition of confiderable ufe: for we can affirm, on the authority of our own obfervations, that the action both of men and of draught horfes does not deviate very far from the proportions of v^2. The obfervations were made on men and horfes tracking a lighter along a canal, and working feveral days together, without having any knowledge of the purpofe of the obfervations. The force exerted was firft meafured by the curvature and weight of the track rope, and afterwards by a fpring fteelyard. This was multiplied by the number of yards per hour, and the product confidered as the momentum. We found the action of men to be very nearly as $\overline{e-m}^2$. The action of horfes, loaded fo as not to be able to trot, was nearly as $\overline{e-m}^{1,7}$.

The practitioner can eafily avail himfelf of the maxim, although the function q fhould never be reduced to any algebraic form. He has only to inftitute a train of experiments on the natural agent, and felect that velocity which gives the higheft product when multiplied by its correfponding preffure.

30

Two methods of availing ourfelves of this maxim.

When this felection has been made, we have two ways of giving our working machines the maximum of effect, having once afcertained the preffure f which our natural power exerts on the impelled point of the machine when it is not allowed to move.

1. When the refiftance arifing from the work, and from friction, is a given quantity; as when water is to be raifed to a certain height by a pifton of given dimenfions.

Since the friction in all the communicating parts of the machine vary in the fame proportion with the preffure, and fince thefe vary in the fame proportion with the refiftance, the fum of the refiftance and friction may be reprefented by $b\,r$, b being an abftract number. Let n be the undetermined velocity of the working point; or let $m : n$ be the proportion of velocities at the impelled and working points. Then, becaufe the preffures at thefe points balance each other, in the cafe of uniform motion, they are inverfely as the velocities at thofe points. Therefore we muft make $b\,r : p = m : n$, and $n = \frac{p\,m}{b\,r} = \frac{\frac{q^q}{\overline{q+1}^q} f m}{b\,r}, = m \frac{q^q f}{\overline{q+1}^q\, b r}$, or $m : n = \overline{q+1}^q \times b\,r : q^q f$.

2. On the other hand, when $m : n$ is already given, by the conftruction of the machine, but $b\,r$ is fufceptible of variation, we muft load the machine with more and more work, till we have reduced the velocity of its impelled point to $\frac{e}{q+1}$.

In either cafe, the performance is expreffed by what expreffes $p\,m$, that is, by $f e \times \frac{q^q}{\overline{q+1}^{q+1}}$. But the ufeful performance, which is really the work done, will be had by dividing the value now obtained by the number b, which expreffes the fum of the refiftance overcome by the working point and the friction of the machine.

Recapitulation.

What has been now delivered contains, we imagine, the chief principles of the theory of machines, and points out the way in which we muft proceed in applying them to every cafe. The reader, we hope, fees clearly the imperfection of a confideration

tion of machines which proceeds no farther than the ftatement of the proportions of the fimultaneous preffures which are excited in all the parts of the machine by the application of the external forces, which we are accuftomed to call the *power* and the *weight*. Unlefs we take alfo into confideration the immediate effect of mechanical force applied to body, and combine this with all the preffures which ftatical principles have enabled us to afcertain, and by this combination be able to fay what portion of unbalanced force there is acting at one and all of the preffing points of the machine, and what will be the motion of *every part* of it in confequence of this overplus, we have acquired no knowledge that can be of fervice to us. We have been contemplating, not a working machine, but a fort of balance. But, by reafoning about thefe unbalanced forces in the fame fimple manner as about the fall of heavy bodies, we were able to difcover the momentary accelerations of every part, and the fenfible motion which it would acquire in any affigned time, if all the circumftances remain the fame. We found that the refults, although deduced from unqueftionable principles, were quite unlike the obferved motions of moft working machines. Proceeding ftill on the fame principles, we confidered this deviation as the indication, and the precife meafure, of fomething which we had not yet attended to, but which the deviation brought into view, and enabled us to afcertain with accuracy. Thefe are the changes which happen in the exertions of our actuating powers by the velocity with which we find it convenient to make them act. Thus we learn more of the nature of thofe powers; and we found it neceffary to diftinguifh carefully between the apparent magnitude of our actuating power and its real exertion in doing our work. This confideration led us to a fundamental propofition concerning all working machines when they have attained an uniform motion; namely, that the power and refiftance then really exerted on the machine precifely balance each other, and that the machine is precifely in the condition of a fteelyard loaded with its balanced weights, and moved round its axis by fome external force diftinct from the power and the weight. We found that this force is the previous overplus of impelling power, before the machine had acquired the uniform motion; and on this occafion we learned to eftimate the effect produced, by the momentum (depending on the form of the machine) of the quantity of motion produced in the whole affemblage of power, refiftance, and machine.

31 Theory of machines ftill intricate, efpecially of fuch as reciprocate.

The theory of machines feemed to be now brought back to that fimplicity of equilibrium which we had faid was fo imperfect a foundation for a theory; but in the availing ourfelves of the maxim founded on this general propofition, we faw that the equilibrium is of a very different kind from a quiefcent equilibrium. It neceffarily involves in it the knowledge of the momentary accelerations and their momenta; without which we fhould not perceive that one ftate of motion is more advantageous than another, becaufe all give us the fame proportion of forces in equilibrio.

But this is not the only ufe of the previous knowledge of the momentary accelerations of machines; there are many cafes where the machine works in this very ftate. Many machines accelerate throughout while performing their work; and their efficacy depends entirely on the final acceleration. Of this kind is the coining prefs, the great forge or tilt mill, and fome other capital engines. The fteam engine, and the common pump, are neceffarily of this clafs, although their efficacy is not eftimated by their final acceleration. A great number of engines have reciprocating motions in different fubordinate parts. The theory of all fuch engines requires for its perfection an accurate knowledge of the momentary accelerations; and we muft ufe the formulæ contained in the firft part of this article.

32 Working and returning ftrokes.

Still, however, the application of this knowledge has many difficulties, which make a *good* theory of fuch machines a much more intricate and complicated matter than we have yet led the reader to fuppofe. In moft of thefe engines, the whole motion may be divided into two parts. One may be called the WORKING STROKE, and the other in which the working points are brought back to a fituation which fits them for acting again, may be called the RETURNING STROKE. This return muft be effected either by means of fome immediate application of the actuating power, or by fome other force, which is counteracted during the working ftroke, and muft be confidered as making part of the refiftance. In the fteam engine, it is generally done by a counterpoife on the outer end of the great working beam. This muft be accounted a part of the refiftance, for it muft be raifed again; and the proportions of the machine for attaining the maximum muft be computed accordingly. The quantity of this counterpoife muft be adjufted by other confiderations. It muft be fuch, that the defcent of the pump rods in the pit may *juft employ the whole time* that is neceffary for filling the cylinder with fteam. If they defcend more brifkly (which an unfkilful engineer likes to fee), this muft be done by means of a greater counterpoife, and this employs more power to raife it again. Defaguliers defcribes a very excellent machine for raifing water in a bucket by a man's ftepping into an oppofite bucket, and defcending by his preponderancy. When he comes to the bottom, he fteps out, goes up a ftair, and finds the bucket returned and ready to receive him again. This machine is extremely fimple, and perhaps the beft that can be contrived; and yet it is one of the moft likely to be a very bad one. The bucket into which the man fteps muft be brought up to its place again by a preponderancy in the machine when unloaded. It may be returned fooner or later. It fhould arrive precifely at the fame time with the man. If fooner, it is of no ufe, and waftes power in raifing a counterpoife which is needlefsly heavy: if later, time is loft: Therefore, the perfection of this very fimple machine requires the judicious combination of two maximums, each of which varies in a ratio compounded of two other ratios. Suppofe the man to employ a minute to go up ftairs 50 feet, which is very nearly what he can do from day to day as his only work, and fuppofe him to weigh 150 pounds, and that he acts by means of a fimple pulley—the maximum for a lever of equal arms would require him to raife about 60 pounds of water. But when all the other circumftances are calculated, it will be found that he muft raife 138 pounds (neglecting the inertia of the machine). He fhould raife 542 pounds 10 feet in a minute; and this is nearly the moft exact valuation of a man's work.

There is the fame neceffity of attending to a variety of of circumſtances in all machines which reciprocate in the whole or any conſiderable part of their motion. The force employed for bringing the machine into another working poſition, muſt be regulated by the time neceſſary for obtaining a new ſupply of power; and then the proportion of m to n muſt be ſo adjuſted, that the work performed, divided by the *whole* time of the working and returning ſtrokes, may give the greateſt quotient. It is ſtill a difficult thing, therefore, to conſtruct a machine in the moſt perfect manner, or even to ſay what will be the performance of a machine already conſtructed; yet we ſee that every circumſtance is ſuſceptible of accurate computation.

With reſpect to machines which acquire a ſort of uniform motion in general, although ſubject to partial reciprocations, as in a pumping, ſtamping, forging engine, it is alſo difficult to aſſign the rate even of this general uniform motion. We may, however, ſay, that it will not be greater than if it were uniform throughout. Were it entirely free from friction, it would be exactly the ſame as if uniform; becauſe the accelerations during the advantageous ſituations of the impelling power would compenſate the retardations. But friction diminiſhes the accelerations, without diminiſhing the retardations.

We may conclude this article with ſome obſervations tending to the general improvement of machines.

33 Uniformity of motion throughout is of great advantage.

Nothing contributes more to the perfection of a machine, eſpecially ſuch as is maſſive and ponderous, than great uniformity of motion. Every regularity of motion waſtes ſome of the impelling power; and it is only the greateſt of the varying velocities which is equal to that which the machine would acquire if moving uniformly throughout; for while the motion accelerates, the impelling force is greater than what balances the reſiſtance then actually oppoſed to it, and the velocity is leſs than what the machine would acquire if moving uniformly: and when the machine attains its greateſt velocity, it attains it becauſe the power is then not acting againſt the whole reſiſtance. In both of theſe ſituations, therefore, the performance of the machine is leſs than if the power and reſiſtance were exactly balanced; in which caſe it would move uniformly.

34 How to attain this.

Every attention ſhould therefore be given to this, and we ſhould endeavour to remove all cauſe of irregularity. The communications of motion ſhould be ſo contrived, that if the impelled point be moving uniformly, by the uniform preſſure of the power, the working point ſhall alſo be moving uniformly. Then we may generally be certain, that the maſſy parts of the machine will be moving uniformly. When this is not done through the whole machine, there are continual returns of ſtrains and jolts; the inertia of the different parts acting in oppoſite directions. Although the whole momenta may always balance each other, yet the general motion is hobbling, and the points of ſupport are ſtrained. A great engine ſo conſtructed, commonly cauſes the building to tremble; but when uniform motion pervades the whole machine, the inertia of each part tends to preſerve this uniformity, and all goes ſmoothly. It is alſo deſerving of remark, that when the communications are ſo contrived that the uniform motion of one part produces uniform motion on the next, the preſſures at the communicating points remain conſtant or invariable. Now the accompliſhing of this is always within the reach of mechanics.

35 Beſt form for the teeth of wheels. Plate XXXIII. fig. 1.

One of the moſt uſual communications in machinery is by means of toothed wheels acting on each other. It is of importance to have the teeth ſo formed, that the preſſure by which one of them A urges the other B round its axis ſhall be conſtantly the ſame. It can eaſily be demonſtrated, that when this is the caſe, the uniform angular motion of the one will produce a uniform angular motion of the other: or, if the motions are thus uniform, the preſſures are invariable. This is accompliſhed on this principle, that the mutual actions of ſolid bodies on each other in the way of preſſure are perpendicular to the touching ſurfaces. Therefore let the tooth a preſs on the tooth b in the point C; and draw the line FCDE perpendicular to the touching ſurfaces in the point C. Draw AF, BE perpendicular to FE, and let FE cut the line AB in D. It is plain, from the common principles of mechanics, that if the line FE, drawn in the manner now deſcribed, always paſs through the ſame point D, whatever may be the ſituation of the acting teeth, the mutual action of the wheels will always be the ſame. It will be the ſame as if the arm AD acted on the arm BD. In the treatiſes on the conſtruction of mills, and other works of this kind, are many inſtructions for the formation of the teeth of wheels; and almoſt every noted millwright has his own noſtrums. Moſt of them are egregiouſly faulty in reſpect of mechanical principle. Indeed they are little elſe than inſtructions how to make the teeth clear each other without ſticking. Mr de la Hire firſt pointed out the above-mentioned principle, and juſtly condemned the common practice of making the ſmall wheel or pinion in the form of a lantern (whence it alſo took its name), conſiſting of two round diſks, having a number of cylindrical ſpokes (fig. 2.) The ſlighteſt inſpection of this conſtruction ſhews that, in the different ſituations of the working teeth, the line FCE continually changes its interſection with AB. If the wheel B be very ſmall in compariſon of the other, and if the teeth of A take deep hold of the cylindrical pins of B, the line of action EF is ſometimes ſo diſadvantageouſly placed, that the preſſure of the one wheel has ſcarcely any tendency at all to turn the other. Mr de la Hire, or Dr Hooke, was, we think, the firſt who inveſtigated the form of tooth which procured this conſtant action between the wheels; and in a very ingenious diſſertation, publiſhed among the Memoirs of the Academy of Sciences at Paris 1668, the former of theſe gentlemen ſhews that this will be enſured by forming the teeth into epicycloids. Mr Camus of the ſame Academy has publiſhed an elaborate diſſertation on the ſame ſubject, in which he proſecutes the principle of Mr de la Hire, and applies it to all the variety of caſes which can occur in practice. There is no doubt as to the goodneſs of the principle; and it has another excellent property, "that the mutual action of the teeth is abſolutely without any friction." The one tooth only applies itſelf to the other, and rolls on it, but does not ſlide or rub in the ſmalleſt degree. This makes them laſt long, or rather does not allow them to wear in the leaſt. But the conſtruction is ſubject to a limitation which muſt not be neglected. The teeth muſt be ſo made, that the curved part of the tooth b is acted on by a flat part of the tooth a till it comes to the line AB in the courſe of its action; after which

Epicycloids recommended by De la Hire.

which the curved part of *a* acts on a flat part of *b*; or the whole action of *a* on *b* is either completed, or only begins at the line AB, joining the centres of the wheels.

36 A better form.

Another form of the teeth ſecures the perfect uniformity of action without this limitation, which requires very nice execution. Let the teeth of each wheel be formed by evolving its circumference; that is, let the acting face GCH of the tooth *a* have the form of the curve traced by the extremity of the thread FC, unlapped from the circumference. In like manner, let the acting face of the tooth *b* be formed by unlapping a thread from its circumference. It is evident, that the line FCE, which is drawn perpendicularly to the touching ſurfaces in the point C, is juſt the direction or poſition of the evolving threads by which the two acting faces are formed. This line muſt therefore be the common tangent to the two circles or circumferences of the wheels, and will therefore always cut the line AB in the ſame point D. This form allows the teeth to act on each other through the whole extent of the line FCE, and therefore will admit of ſeveral teeth to be acting at the ſame time (twice the number that can be admitted in Mr de la Hire's method). This, by dividing the preſſure among ſeveral teeth, diminiſhes its quantity on any one of them, and therefore diminiſhes the dents or impreſſions which they unavoidably make on each other. It is not altogether free from ſliding and friction, but the whole of it can hardly be ſaid to be ſenſible. The whole ſlide of a tooth three inches long, belonging to a wheel of ten feet diameter, acting on a tooth of a wheel of two feet diameter, does not amount to $\frac{1}{16}$th of an inch; a quantity altogether inſignificant.

In the formation of the teeth of wheels, a ſmall deviation from theſe perfect forms is not perhaps of very great importance, except in caſes where a very large wheel drives a very ſmall one (a thing which a good engineer will always avoid). As the conſtruction, however, is exceedingly eaſy, it would be unpardonable to omit it. Well formed teeth, and a great number of them acting at once, make the communication of motion extremely ſmooth and uniform. The machine works without noiſe, and the teeth laſt a very long time without ſenſibly changing their ſhape. But there are caſes, ſuch as the pallets of clocks and watches, where the utmoſt accuracy of form is of the greateſt importance for the perfection of the work.

37 Maxim for the conſtruction of ſtampers, &c.

When heavy ſtampers are to be raiſed, in order to drop on the matters to be pounded, the wipers by which they are lifted ſhould be made of ſuch a form, that the ſtamper may be raiſed by a uniform preſſure, or with a motion almoſt perfectly uniform. If this is not attended to, and the wiper is only a pin ſticking out from the axis, the ſtamper is forced into motion at once. This occaſions violent jolts to the machine, and great ſtrains on its moving parts and their points of ſupport; whereas, when they are gradually lifted, the inequality of deſultory motion is never felt at the impelled point of the machine. We have ſeen piſtons moved by means of a double rack on the piſton rod. A half wheel takes hold of one rack, and raiſes it to the required height. The moment the half wheel has quitted that ſide of the rack, it lays hold of the other ſide, and forces the piſton down again. This is propoſed as a great improvement; correcting the unequable motion of the piſton moved in the common way by a crank. But it is far inferior to the crank motion. It occaſions ſuch abrupt changes of motion, that the machine is ſhaken by jolts. Indeed if the movement were accurately executed, the machine would be ſhaken to pieces, if the parts did not give way by bending and yielding. Accordingly, we have always obſerved that this motion ſoon failed, and was changed for one that was more ſmooth. A judicious engineer will avoid all ſuch ſudden changes of motion, eſpecially in any ponderous part of a machine.

When ſeveral ſtampers, piſtons, or other reciprocal movers, are to be raiſed and depreſſed, common ſenſe teaches us to diſtribute their times of action in a uniform manner, ſo that the machine may always be equally loaded with work. When this is done, and the obſervations in the preceding paragraph attended to, the machine may be made to move almoſt as ſmoothly as if there were no reciprocations in it. Nothing ſhews the ingenuity of the author more than the artful yet ſimple and effectual contrivances for obviating thoſe difficulties that unavoidably ariſe from the very nature of the work that muſt be performed by the machine, and of the power employed. The inventive genius and ſound judgment of Watt and Boulton are as perceptible to a ſkilled obſerver in theſe ſubordinate parts of ſome of their great engines, as in the original diſcovery on which their patent is founded. In ſome of thoſe engines the maſs of deed matter which muſt be put into motion, and this motion deſtroyed and again reſtored in every ſtroke, is enormous, amounting to above an hundred tons. The ingenious authors have even contrived to draw ſome advantages from it, by allowing a great want of equilibrium in certain poſitions; and this has been condemned as a blunder by engineers who did not ſee the uſe made of it.

38 The unavoidable inequalities of moving power muſt be compenſated by the conſtruction.

There is alſo great room for ingenuity and good choice in the management of the moving power, when it is ſuch as cannot immediately produce the kind of motion required for effecting the purpoſe. We mentioned the converſion of the continued rotation of an axis into the reciprocating motion of a piſton, and the improvement which was thought to have been made on the common and obvious contrivance of a crank, by ſubſtituting a double rack on the piſton rod, and the inconvenience ariſing from the jolts occaſioned by this change. We have ſeen a great forge, where the engineer, in order to avoid the ſame inconvenience ariſing from the abrupt motion given to the great ſledge hammer of ſeven hundred weight, reſiſting with a five-fold momentum, formed the wipers into ſpirals, which communicated motion to the hammer almoſt without any jolt whatever; but the reſult was, that the hammer roſe no higher than it had been raiſed in contact with the wiper, and then fell on the iron bloom with very little effect. The cauſe of its inefficiency was not gueſſed at; but it was removed, and wipers of the common form were put in place of the ſpirals. In this operation, the rapid motion of the hammer is abſolutely neceſſary. It is not enough to *lift* it up; it muſt be *toſſed* up, ſo as to fly higher than the wiper lifts it, and to ſtrike with great force the ſtrong oaken ſpring which is placed in its way. It compreſſes this ſpring, and is reflected by it with a conſiderable velocity, ſo as to hit the iron as if it had fallen from a great height. Had it it been allowed to fly to that height, it would have fallen upon the iron with ſomewhat more force (becauſe no oaken ſpring is perfectly elaſtic); but this would have required more than twice the time.

38 Great inconveniences of a reciprocating power.

In employing a power which of neceſſity reciprocates, to drive machinery which requires a continuous motion (as in applying the ſteam engine to a cotton or a griſt mill), there alſo occur great difficulties. The neceſſity of reciprocation in the firſt mover waſtes much power; becauſe the inſtrument which communicates ſuch an enormous force muſt be extremely ſtrong, and be well ſupported. The impelling power is waſted in imparting, and afterwards deſtroying, a vaſt quantity of motion in the working beam. The ſkilful engineer will attend to this, and do his utmoſt to procure the neceſſary ſtrength of this firſt mover, without making it a vaſt load of inert matter. He will alſo remark, that all the ſtrains on it, and on its ſupports, are changing their directions in every ſtroke. This requires particular attention to the manner of ſupporting it. If we obſerve the ſteam engines which have been long erected, we ſee that they have uniformly ſhaken the building to pieces. This has been owing to the ignorance or inattention of the engineer in this particular. They are much more judiciouſly erected now, experience having taught the moſt ignorant that no building can withſtand their deſultory and oppoſite jolts, and that the great movements muſt be ſupported by a frame-work independent of the building of maſonry which contains it (B).

The engineer will alſo remark, that when a ſingle ſtroke ſteam engine is made to turn a mill, all the communications of motion change the direction of their preſſure twice every ſtroke. During the working ſtroke of the beam, one ſide of the teeth of the intervening wheels is preſſing the machinery forward; but during the returning ſtroke, the machinery, already in motion, is dragging the beam, and the wheels are acting with the other ſide of the teeth. This occaſions a rattling at every change, and makes it proper to faſhion both ſides of the teeth with the ſame care.

It will frequently conduce to the good performance of an engine, to make the action of the reſiſting work unequable, accommodated to the inqualities of the impelling power. This will produce a more uniform motion in machines in which the momentum of inertia is inconſiderable. There are ſome beautiful ſpecimens of this kind of adjuſtment in the mechaniſm of animal bodies.

39 Nature, operation, and uſe of a Fly.

It is very cuſtomary to add what is called a FLY to machines. This is a heavy diſk or hoop, or other maſs of matter, *balanced on its axis*, and ſo connected with the machinery as to turn briſkly round with it. This may be done with the view of rendering the motion of the whole more regular, notwithſtanding unavoidable inequalities of the accelerating forces, or of the reſiſtances occaſioned by the work. It becomes a REGULATOR. Suppoſe the reſiſtance extremely unequal, and the impelling power perfectly conſtant; as when a bucket wheel is employed to work *one* pump. When the piſton has ended its working ſtroke, and while it is going down the barrel, the power of the wheel being ſcarcely oppoſed, it accelerates the whole machine, and the piſton arrives at the bottom of the barrel with a conſiderable velocity. But in the riſing again, the wheel is oppoſed by the column of water now preſſing on the piſton. This immediately retards the wheel; and when the piſton has reached the top of the barrel, all the acceleration is undone, and is to begin again. The motion of ſuch a machine is very hobbling: but the ſuperplus of accelerating force at the beginning of a returning ſtroke will not make ſuch a change in the motion of the machine if we connect the fly with it. For the accelerating momentum is a determinate quantity. Therefore, if the radius of the fly be great, this momentum will be attained by communicating a ſmall angular motion to the machine. The momentum of the fly is as the ſquare of its radius; therefore it reſiſts acceleration in this proportion; and although the overplus of power generates the ſame momentum of rotation in the whole machine as before, it makes but a ſmall addition to its velocity. If the diameter of the fly be doubled, the augmentation of rotation will be reduced to one-fourth. Thus, by giving a rapid motion to a ſmall quantity of matter, the great acceleration, during the returning ſtroke of the piſton, is prevented. This acceleration continues, however, during the whole of the returning ſtroke, and at the end of it the machine has acquired its greateſt velocity. Now the working ſtroke begins, and the overplus of power is at an end. The machine accelerates no more; but if the power is juſt in equilibrio with the reſiſtance, it keeps the velocity which it has acquired, and is ſtill more accelerated during the *next* returning ſtroke. But now, at the beginning of the ſubſequent working ſtroke, there is an overplus of reſiſtance, and a retardation begins, and continues during the whole riſe of the piſton; but it is inconſiderable in compariſon of what it would have been without the fly; for the fly, retaining its acquired momentum, drags forward the reſt of the machine, aiding the impelling power of the wheel. It does this by all the communications taking into each other in the oppoſite direction. The teeth of the intervening wheels are heard to drop from their former contact on one ſide, to a contact on the other. By conſidering this proceſs with attention, we eaſily perceive that, in a few ſtrokes, the overplus of power during the returning ſtroke comes to be ſo adjuſted to the deficiency during the working ſtroke, that the accelerations and retardations exactly deſtroy each other, and every ſucceeding ſtroke is made with the ſame velocity, and an equal number of ſtrokes is made in every ſucceeding minute. Thus the machine acquires a general uniformity with periodical inequalities. It is plain, that by ſufficiently enlarging either the diameter or the weight

(B) The gudgeons of a water-wheel ſhould never reſt on the wall of the building. It ſhakes it; and if ſet up ſoon after the building has been erected, it prevents the mortar from taking firm bond; perhaps by ſhattering the calcareous cryſtals as they form. When the engineer is obliged to reſt the gudgeons in this way, they ſhould be ſupported by a block of oak laid a little hollow. This ſoftens all tremors, like the ſprings of a wheel carriage. This practice would be very ſerviceable in many other parts of the conſtruction.

weight of the fly, the irregularity of the motion may be rendered as ſmall as we pleaſe. It is much better to enlarge the diameter. This preſerves the friction more moderate, and the pivot wears leſs. For theſe reaſons, a fly is in general a conſiderable improvement in machinery, by equaliſing many exertions that are naturally very irregular. Thus, a man working at a common windlaſs, exerts a very irregular preſſure on the winch. In one of his poſitions in each turn he can exert a force of near 70 pounds without fatigue, but in another he cannot exert above 25; nor muſt he be loaded with much above this in general. But if a large fly be conected properly with the windlaſs, he will act with equal eaſe and ſpeed againſt 30 pounds.

40
It is a powerful regulator.

This regulating power of the fly is without bounds, and may be uſed to render uniform a motion produced by the moſt deſultory and irregular power. It is thus that the moſt regular motion is given to mills that are driven by a ſingle ſtroke ſteam engine, where for two or even three ſeconds there is no force preſſing round the mill. The communication is made through a maſſive fly of very great diameter, whirling with great rapidity. As ſoon as the impulſe ceaſes, the fly, continuing its motion, urges round the whole machinery with almoſt unabated ſpeed. At this inſtant all the teeth, and all the joints, between the fly and the firſt mover, are heard to catch in the oppoſite direction.

If any permanent change ſhould happen in the impelling power, or in the reſiſtance, the fly makes no obſtacle to its producing its full effect on the machine; and it will be obſerved to accelerate or retard uniformly, till a new general ſpeed is acquired exactly correſponding with this new power and reſiſtance.

Many machines include in their conſtruction movements which are equivalent with this intentional regulator. A flour mill, for example, cannot be better regulated than by its millſtone: but in the Albion mills, a heavy fly was added with great propriety; for if the mills had been regulated by their millſtones only, then at every change of ſtroke in the ſteam engine, the whole train of communications between the beam, which is the firſt mover, and the regulating millſtone, which is the very laſt mover, would take in the oppoſite direction. Although each drop in the teeth and joints be but a trifle, the whole, added together, would make a conſiderable jolt. This is avoided by a regulator immediately adjoining to the beam. This continually preſſes the working machinery in one direction. So judiciouſly were the movements of that noble machine contrived, and ſo nicely were they executed, that not the leaſt noiſe was heard, nor the ſlighteſt tremor felt in the building.

Mr Valoué's beautiful pile engine employed at Weſtminſter Bridge is another remarkable inſtance of the regulating power of a fly*. When the ram is dropped, and its follower diſengaged immediately after it, the horſes would inſtantly tumble down, becauſe the load, againſt which they had been ſtraining hard, is at once taken off; but the gin is connected with a very large fly, which checks any remarkable acceleration, allowing the horſes to lean on it during the deſcent of the load; after which their draught recommences immediately. The ſpindles, cards, and bobbins, of a cotton mill, are alſo a ſort of flies. Indeed all bulky machines of the rotative kind tend to preſerve their motion with ſome degree of ſteadineſs, and their great momentum of inertia is as uſeful in this reſpect as it is prejudicial to the acceleration or any reciprocation when wanted.

* See PILE-Engine, Encycl.

41
A bad conſtruction of a fly.

There is another kind of regulating fly, conſiſting of wings whirled briſkly round till the reſiſtance of the air prevents any great acceleration. This is a very bad one for a *working* machine, for it produces its effect by *really waſting* a part of the moving power. Frequently it employs a very great and unknown part of it, and robs the proprietor of much work. It ſhould never be introduced into any machine employed in manufactures.

42
A conical pendulum is the moſt perfect regulator.

Some rare caſes occur where a very different regulator is required; where a certain determined velocity is found neceſſary. In this caſe the machine is furniſhed, at its extreme mover, with a conical pendulum, conſiſting of two heavy balls hanging by rods, which move in very nice and ſteady joints at the top of a vertical axis. It is well known, that when this axis turns round, with an angular velocity ſuited to the length of thoſe pendulums, the time of a revolution is determined. Thus, if the length of each pendulum be $39\frac{1}{7}$ inches, the axis will make a revolution in two ſeconds very nearly. If we attempt to force it more ſwiftly round, the balls will recede a little from the axis, but it employs as long time for a revolution as before; and we cannot make it turn ſwifter, unleſs the impelling power be increaſed beyond all probability; in which caſe the pendulum will fly out from the centre till the rods are horizontal, after which every encreaſe of power will accelerate the machine very ſenſibly. Watt and Boulton have applied this contrivance with great ingenuity to their ſteam engines, when they are employed for driving machinery for manufactures which have a very changeable reſiſtance, and where a certain ſpeed cannot be much departed from without great inconvenience. They have connected this receſs of the balls from the axis (which gives immediate indication of an increaſe of power or a diminution of reſiſtance) with the cock which admits the ſteam to the working cylinder. The balls flying out, cauſe the cock to cloſe a little, and diminiſh the ſupply of ſteam. The impelling power diminiſhes the next moment, and the balls again approach the axis, and the rotation goes on as before, although there may have occurred a very great exceſs or deficiency of power. The ſame contrivance may be employed to raiſe or lower the feeding ſluice of a water mill employed to drive machinery.

43
A fly ſometimes collects power.

A fly is ſometimes employed for a very different purpoſe from that of a regulator of motion—it is employed as a *collector of power*. Suppoſe all reſiſtance removed from the working point of a machine furniſhed with a very large or heavy fly immediately connected with the working point When a ſmall force is applied to the impelled point of this machine, motion will begin in the machine, and the fly begin to turn. Continue to preſs uniformly, and the machine will accelerate. This may be continued till the fly has acquired a very rapid motion, If at this moment a reſiſting body be applied to the working point, it will be acted on with very great force; for the fly has now accumulated in its circumference a very great momentum. If a body were expoſed immediately to the action of this circumference, it would be violently ſtruck. Much more will it be ſo, if the body be expoſed to the action of the working

working point, which perhaps makes one turn while the fly makes a hundred. It will exert a hundred times more force there (very nearly) than at its own circumference. All the motion which has been accumulated on the fly during the whole progreſs of its acceleration is exerted in an inſtant at the working point, multiplied by the momentum depending on the proportion of the parts of the machine. It is thus that the coining preſs performs its office; nay, it is thus that the blackſmith forges a bar of iron. Swinging the great ſledge hammer round his head, and urging it with force the whole way, this accumulated motion is at once extinguiſhed by impact on the iron. It is thus we drive a nail; and it is thus that by accumulating a very moderate force exerted during four or five turns of a fly, the whole of it is exerted on a punch ſet on a thick plate of iron, ſuch as is employed for the boilers of ſteam engines. The plate is pierced as if it were a bit of cheeſe. This accumulating power of a fly has occaſioned many who think themſelves engineers to imagine, that a fly really adds power or mechanical force to an engine; and, not underſtanding on what its efficacy depends, they often place the fly in a ſituation where it only added a uſeleſs burden to the machine. It ſhould always be made to move with rapidity. If intended for a mere regulator, it ſhould be near the firſt mover. If it is intended to accumulate force in the working point, it ſhould not be far ſeparated from it. In a certain ſenſe, a fly may be ſaid to add power to a machine, becauſe by accumulating into the exertion of one moment the exertions of many, we can ſometimes overcome an obſtacle that we never could have balanced by the ſame machine unaided by the fly.

It is this accumulation of force which gives ſuch an appearance of power to ſome of our firſt movers. When a man is unfortunately catched by the teeth of a paltry country mill, he is cruſhed almoſt to mummy. The power of the ſtream is conceived to be prodigious; and yet we are certain, upon examination, that it amounts to the preſſure of no more than fifty or ſixty pounds. But it has been acting for ſome time; and there is a milſtone of a ton weight whirling twice round in a ſecond. This is the force that cruſhed the unfortunate man; and it required it all to do it, for the mill ſtopped. We ſaw a mill in the neighbourhood of Elbingroda in Hanover, where there was a contrivance which diſengaged the milſtone when any thing got entangled in the teeth of the wheels. It was tried in our ſight with a head of cabbage. It cruſhed it indeed, but not violently, and would by no means have broken a man's arm.

44 Simplicity of conſtruction recommended.

It is hardly neceſſary to recommend ſimplicity in the conſtruction of machines. This ſeems now ſufficiently underſtood. Multiplicity of motions and communications increaſes frictions; increaſes the unavoidable loſſes by bending and yielding in every part; expoſes to all the imperfections of workmanſhip; and has a great chance of being indiſtinctly conceived, and therefore conſtructed without ſcience. We think the following conſtruction of a capſtan or crab a very good example of the advantages of ſimplicity. It is the invention of an untaught but very ingenious country tradeſman.

Fig. 3. EAB is the barrel of the capſtan, ſtanding vertically in a proper frame, as uſual, and urged round by bars ſuch as EF. The upper part A of the barrel is 17 inches in diameter, and the lower B is 16. C is a ſtrong pulley 16 inches in diameter, having a hook D, which takes hold of a hawſer attached to the load. The rope ACB is wound round the barrel A, paſſes over the pulley C, and is then wound round the barrel B in the oppoſite direction. No farther deſcription is neceſſary, we think, to ſhew that, by heaving by the bar F, ſo as to wind more of the rope upon A, and unwind it from B, the pulley C muſt be brought nearer to the capſtan by about three inches for each turn of the capſtan; and that this ſimple capſtan is equivalent to an ordinary capſtan of the ſame length of bar EF, and diameter of barrel B, combined with a 16 fold tackle of pulleys; or, in ſhort, that it is 16 times more powerful than the common capſtan; free from the great loſs by friction and bending of ropes, which would abſorb a third of the power of a 16 fold tackle; and that whereas all other engines become weaker as they multiply the power to a greater degree (unleſs they are proportionally more bulky), this engine becomes really ſtronger in itſelf. Suppoſe we wanted to have it twice as powerful as at preſent; nothing is neceſſary but to cover the part B of the barrel with laths a quarter of an inch thick. In ſhort, the nearer the two barrels are to equality, the more powerful does it become. We give it to the public as an excellent capſtan, and as ſuggeſting thoughts which an intelligent engineer may employ with great effect. By this contrivance, and uſing an iron wire inſtead of a catgut, we converted a common eight day clock into one which goes for two months.

45 Example of a very ſimple and powerful capſtan.

We intended to conclude this article with ſome obſervations on the chief claſſes of powers which are employed to drive machinery; ſuch as water, wind, atmoſphoric preſſure, gunpowder, and the force of men and other animals, giving ſome notion of their abſolute magnitudes, and the effect which may be expected from them. We ſhould then have mentioned what has been diſcovered as to their variation by a variation of velocity. And we intended to conclude with an account of what knowledge has been acquired concerning friction, and the loſs of power in machinery ariſing from this cauſe, and from the ſtiffneſs of ropes, and ſome other cauſes: But we have not yet been able to bring theſe matters into a connected form, which would ſuggeſt the methods and means of farther information thereon. We muſt endeavour to find another opportunity of communicating to the public what we may yet learn on thoſe ſubjects.

We have now eſtabliſhed the principles on which machines muſt be conſtructed, in order that they may produce the greateſt effect; but it would be improper to diſmiſs the ſubject without ſtating to our readers Mr Bramah's new method of producing and applying a more conſiderable degree of power to all kinds of machinery requiring motion and force, than by any means at preſent practiſed for that purpoſe. This method, for which on the 31ſt of March 1796 he obtained a patent, conſiſts in the application of water or other denſe fluids to various engines, ſo as, in ſome inſtances, to to cauſe them to act with immenſe force; in others, to communicate the motion and powers of one part of a machine to ſome other part of the ſame machine; and, laſtly, to communicate the motion and force of one machine to another, where their local ſituations preclude the application of all other methods of connection.

The firſt and moſt material part of this invention will be clearly underſtood by an inſpection of fig. 4. where "A is a cylinder of iron, or other materials, ſufficiently ſtrong, and bored perfectly ſmooth and cylindrical; into which is fitted the piſton B, which muſt be made perfectly water-tight, by leather or other materials, as uſed in pump-making. The bottom of the cylinder muſt alſo be made ſufficiently ſtrong with the other part of the ſurface, to be capable of reſiſting the greateſt force or ſtrain that may at any time be required. In the bottom of the cylinder is inſerted the end of the tube C; the aperture of which communicates with the inſide of the cylinder, under the piſton B, where it is ſhut with the ſmall valve D, the ſame as the ſuction-pipe of a common pump. The other end of the tube C communicates with the ſmall forcing pump or injector E, by means of which water or other denſe fluids can be forced or injected into the cylinder A, under the piſton B. Now, ſuppoſe the diameter of the cylinder A to be 12 inches, and the diameter of the piſton of the ſmall pump or injector E only one quarter of an inch, the proportion between the two ſurfaces or ends of the ſaid piſtons will be as 1 to 2304; and ſuppoſing the intermediate ſpace between them to be filled with water or other denſe fluid capable of ſufficient reſiſtance, the force of one piſton will act on the other juſt in the above proportion, viz. as 1 is to 2304. Suppoſe the ſmall piſton in the injector to be forced down when in the act of pumping or injecting water into the cylinder A, with the power of 20 cwt. which could eaſily be done by the lever H; the piſton B would then be moved up with a force equal to 20 cwt. multiplied by 2304. Thus is conſtructed a hydro-mechanical engine, whereby a weight amounting to 2304 tons can be raiſed by a ſimple lever, through equal ſpace, in much leſs time than could be done by any apparatus conſtructed on the known principles of mechanics; and it may be proper to obſerve, that the effect of all other mechanical combinations is counteracted by an accumulated complication of parts, which renders them incapable of being uſefully extended beyond a certain degree; but in machines acted upon or conſtructed on this principle, every difficulty of this kind is obviated, and their power ſubject to no finite reſtraint. To prove this, it will be only neceſſary to remark, that the force of any machine acting upon this principle can be increaſed *ad infinitum*, either by extending the proportion between the diameter of the injector and the cylinder A, or by applying greater power to the lever H.

"Fig. 5. repreſents the ſection of an engine, by which very wonderful effects may be produced inſtantaneouſly by means of compreſſed air. AA is a cylinder, with the piſton B fitting air-tight, in the ſame manner as deſcribed in fig. 4. C is a globular veſſel made of copper, iron, or other ſtrong materials, capable of reſiſting immenſe force, ſimilar to thoſe of air guns. D is a ſtrong tube of ſmall bore, in which is the ſtop-cock E. One of the ends of this tube communicates with the cylinder under the piſton B, and the other with the globe C. Now, ſuppoſe the cylinder A to be the ſame diameter as that in fig. 4. and the tube D equal to one quarter of an inch diameter, which is the ſame as the injector fig. 4.: then, ſuppoſe that air is injected into the globe C (by the common method), till it preſſes againſt the cock E with a force equal to 20 cwt. which can eaſily be done; the conſequence will be, that when the cock E is opened, the piſton B will be moved in the cylinder AA with a power or force equal to 2304 tons; and it is obvious, as in the caſe fig. 4. that any other unlimited degree of force may be acquired by machines or engines thus conſtructed.

"Fig. 6. is a ſection, merely to ſhew how the power and motion of one machine may, by means of fluids, be transferred or communicated to another, let their diſtance and local ſituation be what they may. A and B are two ſmall cylinders, ſmooth and cylindrical; in the inſide of each of which is a piſton, made water and air tight, as in figs 4. and 5. CC is a tube conveyed under ground, or otherwiſe, from the bottom of one cylinder to the other, to form a communication between them, notwithſtanding their diſtance be ever ſo great; this tube being filled with water or other fluid, until it touch the bottom of each piſton; then, by depreſſing the piſton A, the piſton B will be raiſed. The ſame effect will be produced *vice verſa:* thus bells may be rung, wheels turned, or other machinery put inviſibly in motion, by a power being applied to either.

"Fig. 7. is a ſection, ſhewing another inſtance of communicating the action or force of one machine to another; and how water may be raiſed out of wells of any depth, and at any diſtance from the place where the operating power is applied. A is a cylinder of any required dimenſions, in which is the working piſton B, as in the foregoing examples: into the bottom of this cylinder is inſerted the tube C, which may be of leſs bore than the cylinder A. This tube is continued, in any required direction, down to the pump cylinder D, ſuppoſed to be fixed in the deep well EE, and forms a junction therewith above the piſton F; which piſton has a rod G, working through the ſtuffing-box, as is uſual in a common pump. To this rod G is connected, over a pulley or otherwiſe, a weight H, ſufficient to overbalance the weight of the water in the tube C, and to raiſe the piſton F when the piſton B is lifted: thus, ſuppoſe the piſton B is drawn up by its rod, there will be a vacuum made in the pump cylinder D, below the piſton F; this vacuum will be filled with water through the ſuction pipe, by the preſſure of the atmoſphere, as in all pumps fixed in air. The return of the piſton B, by being preſſed downwards in the cylinder A, will make a ſtroke of the piſton in the pump cylinder D, which may be repeated in the uſual way by the motion of the piſton B, and the action of the water in the tube C. The rod G of the piſton F, and the weight H, are not neceſſary in wells of a depth where the atmoſphere will overbalance the water in the ſuction of the pump cylinder D, and that in the tube C. The ſmall tube and cock in the ciſtern I, are for the purpoſe of charging the tube C."

That theſe contrivances are ingenious, and may occaſionally prove uſeful, we are not inclined to controvert; but we muſt confeſs, that the advantages of them appear not to us fo great as to their author. Why they do not, we need not explain to any man who, with a fufficient degree of mechanical and mathematical knowledge, has perufed this article with attention. *Mr John Lucock*, however, of Marley, near Leeds, thinks fo very differently from us on this fubject, that, on Mr Bramah's principle, he propofes to apply water or other denfe fluids, fo as to make them fupply the place of fteam in what is commonly called the *fteam engine*. He calls his engine the *paradoxical machine*; and he got a patent for it on the 28th of February 1799, though it differs in nothing from Mr Bramah's machine, reprefented by fig. 4. except that the tube C in the paradoxical machine is fupplied with water, not by means of a forcing pump, but from a ciftern elevated to fuch a height as, that the water defcending through the tube may produce its effect merely by its weight. Whether this variation, for it is no improvement, of Mr Bramah's machine, intitled its author to a patent, it is not our bufinefs to inquire.

Macpherfon.

MACPHERSON (James, Efq;), was born in the parifh of Kingufie, and county of Invernefs, in the year 1738. His father was a farmer of no great affluence; and young Macpherfon received the earlier part of his education in one of the parifh fchools in the diftrict called Badenoch. By an anonymous writer in the Edinburgh Magazine, he is faid to have been educated in the grammar fchool of Invernefs; and he may, for ought that we know to the contrary, have fpent a year in that feminary; but we rather think that he went directly from a country fchool to the univerfity of Aberdeen. At this our readers need not be furprifed; for at the period to which we refer, fome of the parochial fchoolmafters in Scotland, and more efpecially in the Highlands, were men eminent for tafte and claffical literature.

It was in the end of October or the 1ft of November 1752, that James Macpherfon entered the King's College; where he difplayed more genius than learning, entertaining the fociety of which he was a member, and even diverting the younger part of it from their ftudies, by his humorous and doggerel rhimes. About two years after his admiffion into the univerfity, the King's College added two months to the length of its annual *feffion* or *term*; which induced Macpherfon, with many other young men, to remove to the Marifchal College, where the feffion continued fhort; and it is this circumftance which leads us to fuppofe that his father was not opulent.

Soon after he left college, and perhaps before he left it, he was fchoolmafter of Ruthven, or Riven, of Badenoch; and we believe he afterwards delighted as little as his great antagonift Johnfon in the recollection of that period when he was compelled, by the narrownefs of his fortune, to teach boys in an obfcure fchool. It was during this period, we think in 1758, that he publifhed *The Highlander*, an heroic poem in fix cantos, 12mo. Of this work, as we have never feen it, we can fay nothing. By the anonymous writer already quoted, it is mentioned as a "tiffue of fuftian and abfurdity;" whilft others, and they too men of learning and character, have affured us, that it indicated confiderable genius in fo young an author.

Soon after this publication, Mr Macpherfon quitted his fchool, and was received by Mr Graham of Balgowan into his family as tutor to his fons; an employment of which he was not fond, and to which he was not long condemned. In the year 1760 he furprifed the world by the publication of *Fragments of Ancient Poetry, collected in the Highlands of Scotland, and Tranflated from the Gaelic or Erfe Language*, 8vo. Thefe fragments, which were declared to be genuine remains of ancient Scottifh poetry, at their firft appearance delighted every reader; and fome very good judges, and amongft the reft Mr Gray, were extremely warm in their praifes. Macpherfon had intended to bury them in a Scotch magazine, but was prevented from fo injudicious a ftep by the advice of a friend. He publifhed them therefore in a pamphlet by themfelves, and thus laid the foundation of his future fortune.

As other fpecimens were faid to be recoverable, a fubfcription was fet on foot by the Faculty of Advocates at Edinburgh, to enable our author to quit the family of Balgowan, perambulate the Highlands, and fecure, if he could, the precious treafure. He engaged in the undertaking, and was fuccefsful; for all who poffeffed any of the long-famed works, vied with each other in giving or fending them, to a man who had fhewn himfelf fo capable of doing them juftice.

With his collection of poems, and fragments of poems, he went to London; and tagging them together in the form which he thought beft, he publifhed, in 1762, *Fingal, an Ancient Epic Poem, in fix books*, together with feveral other poems, compofed by Offian the fon of Fingal, tranflated from the Gaelic language, 4to. The fubject of this epic poem is an invafion of Ireland by Swaran king of Lochlin. Cuchullin, general of the Irifh tribes during the minority of Cormac, king of Ireland, upon intelligence of the invafion, affembled his forces near Tura, a caftle on the coaft of Ulfter. The poem opens with the landing of Swaran; councils are held, battles fought, and Cuchullin is at laft totally defeated. In the mean time, Fingal, king of the Highlands of Scotland, whofe aid had been folicited before the enemy landed, arrived, and expelled them from the country. This war, which continued but fix days and as many nights, is, including the epifodes, the ftory of the Poem. The fcene, the heath of Lena, near a mountain called Cromleach in Ulfter. This poem alfo was received with equal applaufe as the preceding Fragments.

The next year he produced *Temora*, an ancient epic poem, in eight books; together with feveral other poems compofed by Offian fon of Fingal, 4to; which, though well received, found the public fomewhat lefs difpofed to beftow the fame meafure of applaufe. Tho' thefe poems had been examined by Dr Blair and others, and their authenticity afferted, there were not wanting fome of equal reputation for critical abilities, who either doubted or declared their difbelief of the genuinenefs of them,

them. Into this queſtion it would be ſuperfluous to enter here particularly, as we have ſaid enough on it elſewhere. See Ossian, *Encycl.*

That any man ſhould ſuppoſe Macpherſon, after his tranſlation of Homer, the *author* of the poems which he aſcribes to Oſſian, appears to us very extraordinary; and it is little leſs extraordinary, that any one ſhould, for a moment, believe in the exiſtence of *manuſcripts* of theſe poems of *very high* antiquity. Part of them he undoubtedly received in manuſcript from Macdonald of Clanronald; but we can affirm, on the beſt authority, that the ſaid manuſcript was written at different times by the Macvurichs, hereditary bards to that family. He may likewiſe have received ſhort manuſcripts elſewhere; but every Highland gentleman of learning and of candour (and none elſe have a right to decide on this queſtion), declares, that by much the greater part of the poems had been preſerved in fragments and popular ſongs from a very remote age by oral tradition. To theſe fragments Macpherſon and his aſſociates (A) gave form; and it was by uniting together fragments of different ages, that he inadvertently furniſhed Gibbon and others with the opportunity of objecting, that the poems are ſometimes inconſiſtent with the truth of hiſtory. This, however, is no ſolid objection to their authenticity; for every Weſt Highlander ſixty years of age remembers to have heard, in his youth, great part of thoſe poems repeated by old men; and is confident that, many centuries ago, the names of *Fiune Mackuil* (Fingal), and of Oſſian's other heroes and heroines, were as familiar to a Highland ear, as the names of Agamemnon, Hector, Helen, &c. were to a Grecian ear at the time when the poems of Homer were reduced into their preſent form. For the ſubſtance of the poems, this is ſuch evidence as none will reject who does not prefer his own cobweb theories to the united teſtimony of a whole people.

With reſpect to authenticity, the poems of Oſſian have indeed been compared with the poems of Rowley; but the compariſon is abſurd. The poems of the Celtic bard were not found in an old cheſt, and preſented to a people who had never before heard either of them or of their author; they were the popular ſongs and traditions of ages collected together, and reduced into form, with additions occaſionally made by the tranſlator. It is ridiculous to aſk how theſe ſongs and ſtories could be ſo long preſerved among a rude and illiterate people; for it is only among ſuch a people, whoſe objects of purſuit are too few to occupy all their attention, that the exploits of their anceſtors can be handed down by tradition; and the moſt ſerious objection which we have ever met with to the tranſlator's account of the origin of the poems, ariſes from his having pretended that he received the greater part of them in old manuſcripts.

After the publication of Oſſian's poems, by which we have reaſon to believe that he gained twelve hundred pounds, Mr Macpherſon was called to an employment which withdrew him, for ſome time, both from the muſes and from his country. Captain Johnſtone was appointed governor of Penſacola, and Mr Macpherſon accompanied him as his ſecretary, being at the ſame time made ſurveyor-general of the Floridas. If our memory does not deceive us, ſome difference aroſe between the principal and his dependant, and they parted before their return to England. Having contributed his aid to the ſettlement of the civil government of that colony, he viſited ſeveral of the Weſt India iſlands, and ſome of the provinces of North America, and returned to England in the year 1766, where he retained for life his ſalary as ſurveyor, which we believe was L. 200 a-year.

He ſoon returned to his ſtudies, and in 1771 produced *An Introduction to the Hiſtory of Great Britain and Ireland*, 4to; a work which he ſays, "without any of the ordinary incitements to literary labour, he was induced to proceed in by the ſole motive of private amuſement." The ſubject of this performance, it might reaſonably be ſuppoſed, would not excite any violent controverſial acrimony; yet neither it nor its author could eſcape from ſeveral moſt groſs and bitter invectives; for ſome of which he perhaps gave too great occaſion.

His next performance produced him neither reputation nor profit. In 1773 he publiſhed, *The Iliad of Homer*, tranſlated in two volumes 4to; a work fraught with vanity and ſelf-conſequence, and which met with the moſt mortifying reception from the public. It was condemned by the critics, ridiculed by the wits, and neglected by the world. Some of his friends, and particularly Sir John Elliott, endeavoured to reſcue it from contempt, and force it into notice. Their ſucceſs was not equal to their efforts.

About this time ſeems to be the period of Mr Macpherſon's literary mortifications. In 1773 Dr Johnſon and Mr Boſwell made the tour to the Hebrides; and in the courſe of it, the former took ſome pains to examine into the proofs of the authenticity of Oſſian. The reſult of his inquiries he gave to the public in 1775, in his narrative of the tour; and his opinion was unfavourable. "I believe they (*i. e.* the poems, ſays he), never exiſted in any other form than that which we have ſeen. The editor or author never could ſhew the original; nor can it be ſhewn by any other. To revenge reaſonable incredulity by refuſing evidence, is a degree of inſolence with which the world is not yet acquainted; and ſtubborn audacity is the laſt refuge of guilt. It would be eaſy to ſhew it if he had it. But whence could it be had? It is too long to be remembered, and the language had formerly nothing written. He has doubtleſs inſerted names that circulate in popular ſtories, and may have tranſlated ſome wandering ballads, if any can be found; and the names and ſome of the images being recollected, make an inaccurate auditor imagine that he has formerly heard the whole."

Again, he ſays, "I have yet ſuppoſed no impoſtor but in the publiſher; yet I am far from certainty, that ſome tranſlations have not been lately made, that may,

(A) We have been aſſured that he had aſſociates: and that for the deſcription of Cuchullin's chariot in particular he was indebted to Mr Macpherſon of *Stramazhie*; a man of native genius, and though not poſſeſſed of very extenſive erudition, well acquainted with Gaelic poetry.

Macpherson. may now be obtruded as parts of the original work.

"Credulity on the one part is a strong temptation to deceit on the other, especially to deceit of which no personal injury is the consequence, and which flatters the author with his own ingenuity. The Scots have something to plead for their easy reception of an improbable fiction: they are seduced by their fondness for their supposed ancestors. Neither ought the English to be much influenced by Scots authority; for of the past and present state of the whole Erse nation, the Lowlanders are at least as ignorant as ourselves. To be ignorant is painful; but it is dangerous to quiet our uneasiness by the delusive opiate of hasty persuasion."

These reasonings, if reasonings they can be called, might have been easily answered, had not Macpherson pretended to the possession of at least one manuscript which certainly never existed. He did, however, attempt to answer them; but adopted a mode of proceeding which tended only to convince the world that Johnson's opinion had some foundation, and that the editor of Ossian had more imagination than sound judgement. Prompted by his evil genius, he sent a menacing letter to his illustrious antagonist, which produced the following brief but spirited reply:

"Mr James Macpherson, No date.

"I received your foolish and impudent letter. Any violence that shall be offered to me, I will do my best to repel; and what I cannot do for myself, the law shall do for me; for I will not be hindered from exposing what I think a cheat, by the menaces of a ruffian. What! Would you have me retract? I thought your work an imposition: I think so still; and, for my opinion, I have given reasons, which I dare you to refute. Your abilities, since your *Homer*, are not so formidable; and what I hear of your morality, inclines me to believe rather what you shall prove than what you shall say."

Whether this letter shewed to Macpherson the imprudence of his conduct, or that he had been made sensible of his folly by the interposition of friends, we know not, but certain it is, we hear no more afterwards of this ridiculous affair, except that our author is supposed to have assisted Mr Macnicol in an answer to Dr Johnson's Tour, printed in 1779. This supposition we are enclined to consider as well-founded, because we have been told by a gentleman of veracity, that Mr Macnicol affirms, that the scurrility of his book, which constitutes a great part of it, was inserted, unknown to him, after the manuscript was sent for publication to London.

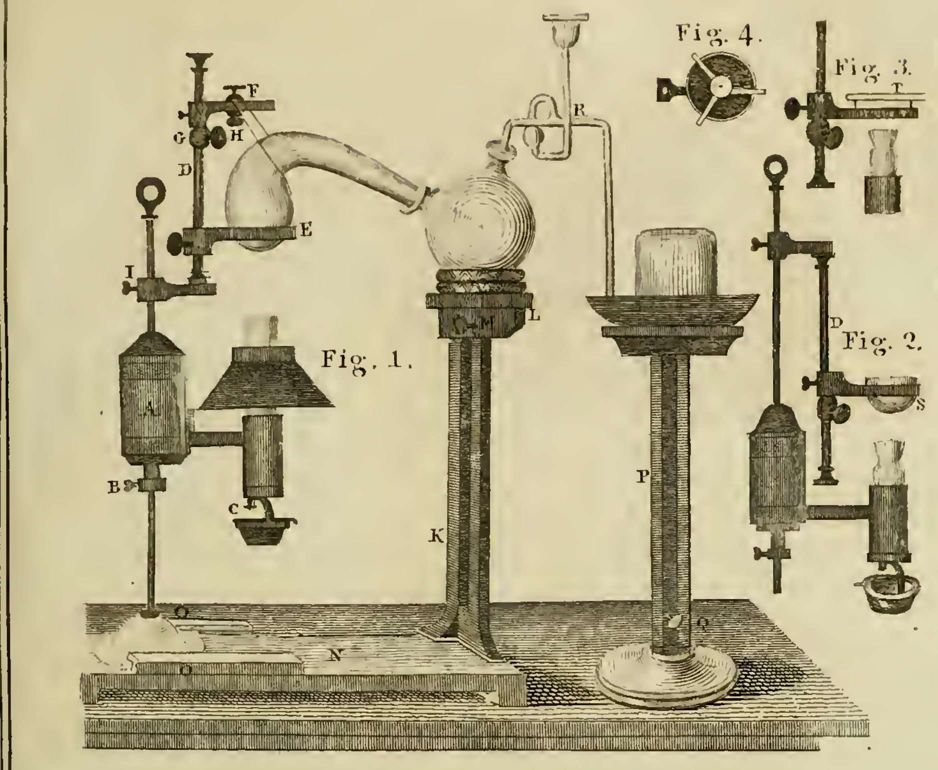
In 1775 Mr Macpherson published *The History of Great Britain from the Restoration to the Accession of the House of Hanover*, in two volumes 4to; a work in our opinion of great merit, though by one party it has been industriously, and, we are sorry to add, too successfully, decried. As an historian, our author could not indeed boast the attic elegance of a Robertson, the splendour of a Gibbon, or the philosophical profundity of a Hume; but his *style*, though it has sometimes been the avowed, was not the real, cause of the coldness with which his history was received. The writer of this sketch once saw a gentleman of rank, and of the Whig interest, turn over one of Macpherson's volumes, and heard him say, upon shutting the book, "I cannot bear that work." He was asked if he thought the narrative false? and he replied, "No! it is too true; but I cannot bear it, because it gives me a bad opinion of those great men to whom I have been accustomed to look back with reverence as to the saviours of my country."

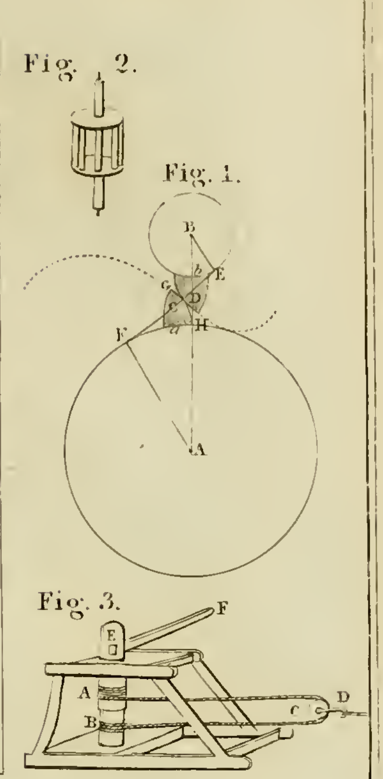
That it has been abhorred by others on the same account, we have not a doubt; and yet language has no name too contemptuous for those who will not follow Truth whithersoever she may lead them; or who, on the absurd pretence of having already made up their minds, will not study the evidence on both sides of a disputed question in our national history. A man needs not surely disapprove of the Revolution, or of the subsequent settlements, though he should find complete proofs that Danby and Sunderland were crooked politicians, that Marlborough was ungrateful, or even that King William himself was not that upright and disinterested character which from their infancy they have been taught to believe. It is no uncommon thing for Divine Providence to accomplish good ends by wicked instruments. Every Protestant surely considers the Reformation as one of the most blessed events that have taken place in the world since the first preaching of the gospel of Christ; yet he would be a hardy champion who should undertake to vindicate the motives which influenced the conduct of the first reformers—of Henry VIII. for instance, or even of Luther himself. And why may not the Revolution be considered as in the highest degree beneficial to the country, though the conduct of some of those who brought it about should be found to be such as Macpherson represents it?

That author certainly acted with great fairness; as together with the history he published the proofs upon which his facts were founded, in two quarto volumes, intitled, *Original Papers, containing the secret History of Great Britain, from the Restoration to the Accession of the House of Hanover; to which are perfixed, Extracts from the Life of James II. as written by himself.* These papers were chiefly collected by Mr Carte, but are not all of equal authority. They, however, clear up many obscurities, and set the characters of many persons in past times in a different light from that in which they have been usually viewed. On this account we have no hesitation to say, that he who is capable of sacrificing prejudice to truth, and wishes to understand the politics of the reigns of James, and William, and Anne, should study with care the volumes of Macpherson.

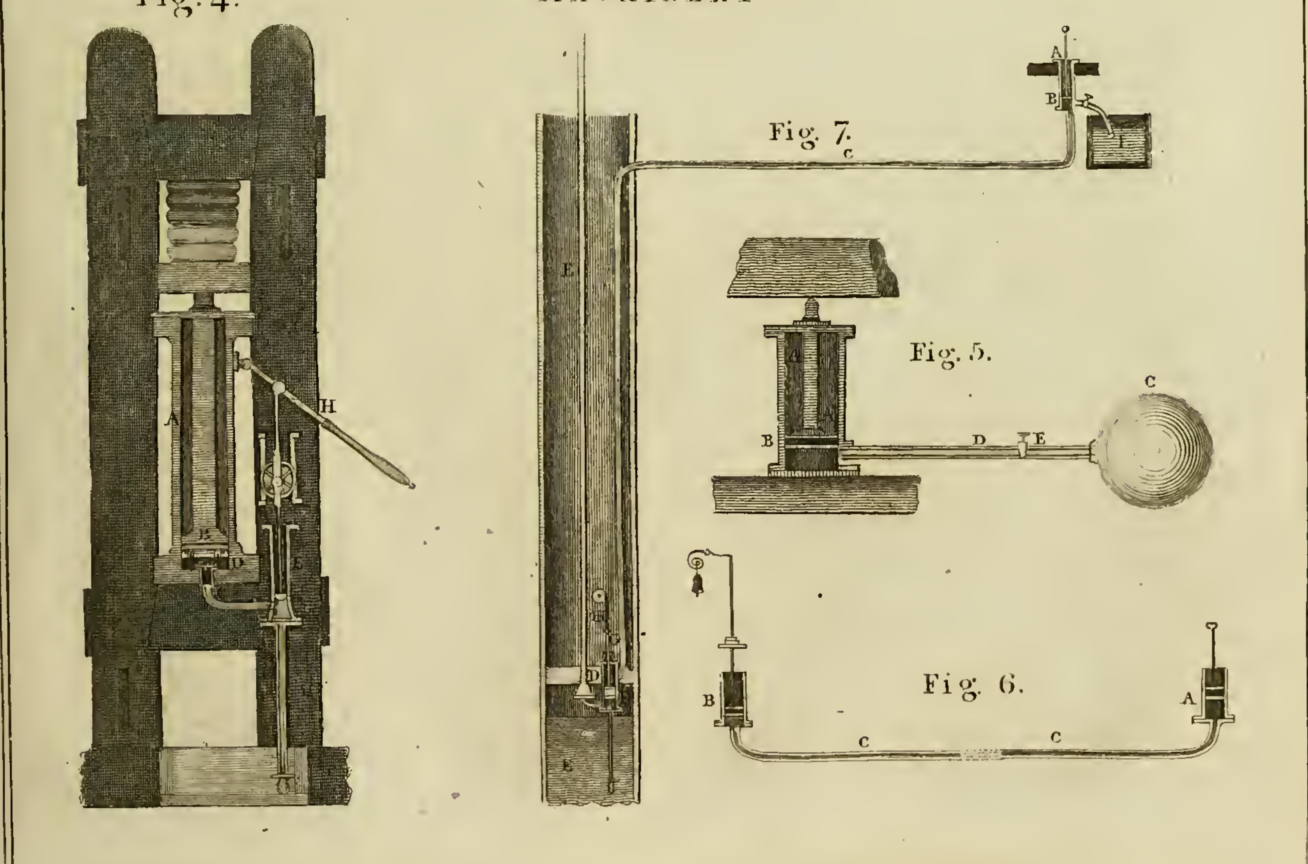
Soon after this period, the tide of fortune flowed very rapidly in Mr Macpherson's favour, and his talents and industry were amply sufficient to avail himself of every favourable circumstance which arose. The resistance of the Colonies called for the aid of a ready writer to combat the arguments of the Americans, and to give force to the reasons which influenced the conduct of government, and he was selected for the purpose. Among other things (of which we should be glad to receive a more particular account), he wrote a pamphlet, which was circulated with much industry, intitled, *The Rights of Great Britain asserted against the Claims of the Colonies; being an Answer to the Declaration of the General Congress*, 8vo, 1776, and of which many editions were published. He also was the author of *A short History of Opposition during the last Session of Parliament*,

LABORATORY. PLATE XXXIII.





MACHINERY



Macpherson.

Parliament, 8vo, 1779; a pamphlet which, on account of its merit, was by many afcribed to Mr Gibbon.

But a more lucrative employment was conferred on him about this time. He was appointed agent to the nabob of Arcot, and in that capacity exerted his talents in feveral appeals to the public in behalf of his client. Among others, he publifhed, *Letters from Mahommed Ali Chan, Nabob of Arcot, to the Court of Directors; to which is annexed, a State of Facts relative to Tanjore, with an Appendix of Original Papers*, 4to, 1777; and he was fuppofed to be the author of *The Hiftory and Management of the Eaft India Company from its Origin in* 1600 *to the prefent Times*, vol. i. containing the affairs of the Carnatic, in which the rights of the nabob are explained, and the injuftice of the Company proved, 4to, 1779.

In his capacity of agent to the nabob, it was probably thought requifite that he fhould have a feat in the Britifh Parliament. He was accordingly in 1780 chofen member for Camelford; but we do not recollect that he ever attempted to fpeak in the Houfe. He was alfo rechofen in 1784 and 1790.

He had purchafed, we think before the year 1790, an eftate in the parifh in which he was born; and changing its name from *Retz* to *Belville*, built on it a large and elegant manfion, commanding a very romantic and picturefque view; and thither he retired, when his health began to fail, in expectation of receiving benefit from the change of air. He continued, however, to decline; and after lingering fome time, died at his feat at Belville, in Invernefs, on the 17th of February 1796.

Macpherfon, Magma.

He appears to have died in very opulent circumftances; and by his will, dated June 1793, gave various annuities and legacies to feveral perfons to a great amount. He alfo bequeathed L. 1000 to John Mackenzie of Figtree Court, in the Temple, London, to defray the expence of printing and publifhing Offian in the original. He directed L. 300 to be laid out in erecting a monument to his memory in fome confpicuous fituation at Belville, and ordered that his body fhould be carried from Scotland, and interred in the Abbey Church of Weftminfter, the city in which he had paffed the beft part of his life. His remains were accordingly taken from the place where he died, and buried in the Poets Corner of Weftminfter Church.

MAGMA is properly the *refufe* of any fubftance which has been fubjected to preffure; but, in chemiftry, the term is fometimes ufed to denote a mixture of two or more bodies, reduced to the confiftence of dough or pafte.

MAGNETISM,

IN natural philofophy.—Our intention in the prefent article was principally to give a more diftinct account of the theory of Mr Æpinus than is contained in the article MAGNETISM of the *Encyclopædia Britannica*, referring for proof and illuftration to the many facts contained in that article: but, on more mature confideration, we concluded, that this method would fret and confufe the reader by continual references, and leave but a feeble impreffion at laft. We have therefore preferred the putting the whole into the form of a fhort treatife on magnetifm, fimilar to our fupplementary article of ELECTRICITY. This, we hope, will be more perfpicuous and fatisfactory; ftill leaving to the reader the full ufe of all the information contained in the article MAGNETISM of the Dictionary.

1
[...]ons the [...]nts [...] ig[...]nt of [...]ral [...]ofophy.

The knowledge which the ancient naturalifts poffeffed of this fubject was extremely imperfect, and affords, we think, the ftrongeft proof of their ignorance of the true method of philofophifing; for there can hardly be named any object of phyfical refearch that is more curious in itfelf, or more likely to engage attention, than the apparent life and activity of a piece of rude unorganifed matter. This had attracted notice in very early times; for Thales attributed the characteriftic phenomenon, the attraction of a piece of iron, to the agency of a mind or foul refiding in the magnet. Philofophers, as they were called, feem to have been contented with this lazy notice of a flight fuggeftion, unbecoming an inquirer, and rather fuch as might be expected from the moft incurious peafant. Even Ariftotle, the moft zealous and the moft fyftematic ftudent of Nature of whofe labours we have any account, has collected no information that is of any importance. We know that the general imperfection of ancient phyfics has been afcribed to the little importance that was attached to the knowledge of the material world by the philofophers of Greece and Rome, who thought human nature, the active purfuits of men, and the fcience of public affairs, the only objects deferving their attention. Moft of the great philofophers of antiquity were alfo great actors on the ftage of human life, and defpifed acquifitions which did not tend to accomplifh them for this dignified employment: but they have not given this reafon themfelves, though none was more likely to be uppermoft in their mind. Socrates diffuades from the ftudy of material nature, not becaufe it was unworthy of the attention of his pupils, but becaufe it was too difficult, and that certainty was not attainable in it. Nothing can more diftinctly prove their ignorance of what is really attainable in fcience, namely, the knowledge of the *laws of nature*, and their ignorance of the only method of acquiring this knowledge, viz. obfervation and experiment. They had entertained the hopes of difcovering the *caufes* of things, and had formed their philofophical language, and their mode of refearch, in conformity with this hopelefs project. Making little advances in the difcovery of the caufes of the phenomena of material nature, they deferted this ftudy for the ftudy of the conduct of man; not becaufe the difcovery of caufes was more eafy and frequent here, but becaufe the ftudy itfelf was more immediately interefting, and becaufe any thing like fuperior knowledge in it puts the poffeffor in the defirable fituation of an advifer, a man of fuperior wifdom; and as this ftudy was clofely connected with morals, becaufe the fear of God is truly the beginning of wifdom, the character of the philofopher acquired an eminence and dignity which was highly flattering to human vanity. Their procedure in the moral and intellectual fciences is ftrongly marked with the fame ignorance of the true method of philofophifing; for we rarely

rarely find them forming general propoſitions on copious inductions of facts in the conduct of men. They always proceed in the ſynthetic method, as if they were fully converſant in the firſt principles of human nature, and had nothing to do but to make the application, according to the eſtabliſhed forms of logic. While we admire, therefore, the ſagacity, the penetration, the candid obſervation, and the happy illuſtration, to be found in the works of the ancient moraliſts and writers on juriſprudence and politics, we cannot but lament that ſuch great men, frequently engaged in public affairs, and therefore having the fineſt opportunities for deducing general laws, have done ſo little in this way; and that their writings, however engaging and precious, cannot be conſidered as any thing more refined than the obſervations of judicious and worthy men, with all the diffuſeneſs and repetition of ordinary converſation. All this has ariſen from the want of a juſt notion of what is attainable in this department of ſcience, namely, the laws of intellectual and moral nature; and of the only poſſible method of attaining this knowledge, viz. obſervation and experiment, and the formation of general laws by the induction of particular facts.

2
Dr Gilbert was the firſt experimental inquirer about magnetiſm.

We have been led into theſe reflections by the inattention of the ancients to the curious phenomena of magnetiſm; which muſt have occurred in conſiderable and entertaining variety to any perſon who had taken to the experimental method. And we have hazarded theſe free remarks, expecting the acquieſcence of our readers, becauſe the ſuperior knowledge which we, in theſe later days, have acquired of the magnetical phenomena, were the firſt fruits of the true method of philoſophiſing. This was pointed out to the learned world in 1590 by our celebrated countryman Chancellor Bacon, in his two great works, the *Novum Organum Scientiarum*, and *De Argumentis Scientiarum*. Dr Gilbert of Colcheſter, a philoſopher of eminence in many reſpects, but chiefly becauſe he had the ſame juſt views of philoſophy with his noble countryman, publiſhed about the ſame time his *Phyſiologia Nova, ſeu Tractatus de Magnete et Corporibus Magneticis*. In the introduction, he recounts all the knowledge of the ancients on the ſubject, and their ſupine inattention to what was ſo entirely in their hands; and the impoſſibility of ever adding to the ſtock of uſeful knowledge, ſo long as men imagined themſelves to be philoſophiſing while they were only repeating a few cant words, and the unmeaning phraſes of the Ariſtotelian ſchool. It is curious to remark the almoſt perfect ſameneſs of Dr Gilbert's ſentiments and language with thoſe of Lord Bacon. They both charge, in a peremptory manner, all thoſe who pretend to inform others, to give over their dialectic labours, which are nothing but ringing changes on a few trite truths, and many unfounded conjectures, and immediately to betake themſelves to experiment. He has purſued this method on the ſubject of magnetiſm with wonderful ardour, and with equal genius and ſucceſs; for Dr Gilbert was poſſeſſed both of great ingenuity, and a mind fitted for general views of things. The work contains a prodigious number and variety of obſervations and experiments, collected with ſagacity from the writings of others, and inſtituted by himſelf with conſiderable expence and labour. It would indeed be a miracle, if all Dr Gilbert's general inferences were juſt, or all his experiments accurate. It was untrodden ground. But, on the whole, this performance contains more real information than any writing of the age in which he lived, and is ſcarcely exceeded by any that has appeared ſince. We may hold it with juſtice as the firſt fruits of the Baconian or experimental philoſophy.

This work of Dr Gilbert's relates chiefly to the loadſtone, and what we call magnets, that is, pieces of ſteel which have acquired properties ſimilar to thoſe of the loadſtone. But he extends the term *magnetiſm*, and the epithet *magnetic*, to all bodies which are affected by loadſtones and magnets in a manner ſimilar to that in which they affect each other. In the courſe of his inveſtigation, indeed, he finds that theſe bodies are only ſuch as contain iron in ſome ſtate or other: and in proving this limitation he mentions a great variety of phenomena which have a conſiderable reſemblance to thoſe which he allows to be magnetical, namely, thoſe which he called *electrical*, becauſe they were produced in the ſame way that amber is made to attract and repel light bodies. He marks with care the diſtinctions between theſe and the characteriſtic phenomena of magnets. He ſeems to have known, that all bodies may be rendered electrical, while ferruginous ſubſtances alone can be made magnetical.

3
His treatiſe contains many diſcoveries.

It is not ſaying too much of this work of Dr Gilbert's to affirm, that it contains almoſt every thing that we know about magnetiſm. His unwearied diligence in ſearching every writing on the ſubject, and in getting information from navigators, and his inceſſant occupation in experiments, have left very few facts unknown to him. We meet with many things in the writings of poſterior inquirers, ſome of them of high reputation, and of the preſent day, which are publiſhed and received as notable diſcoveries, but are contained in the rich collection of Dr Gilbert. We by no means aſcribe all this to mean plagiariſm, although we know traders in experimental knowledge who are not free from this charge. We aſcribe it to the general indolence of mankind, who do not like the trouble of conſulting originals, where things are mixed with others which they do not want, or treated in a way, and with a painful minuteneſs, which are no longer in faſhion. Dr Gilbert's book, although one of thoſe which does the higheſt honour to our country, is leſs known in Britain than on the continent. Indeed we know but of two Britiſh editions of it, which are both in Latin; and we have ſeen five editions publiſhed in Germany and Holland before 1628. We earneſtly recommend it to the peruſal of the curious reader. He will (beſides the ſound philoſophy) find more facts in it than in the two large folios of Scarella.

After this moſt deſerved eulogy on the parent of magnetical philoſophy, it is time to enter on the ſubject.

4
We can only claſs the phenomena.

In mechanical philoſophy, a phenomenon is not to be conſidered as explained, unleſs we can ſhew that it is the certain reſult of the laws of motion applied to matter. It is in this way that the general propoſitions in phyſical aſtronomy, in the theory of machines, in hydraulics, &c. are demonſtrated. But the phenomena called *magnetical* have not as yet obtained ſuch an explanation. We do not ſee their immediate cauſe, nor can we ſay with confidence that they are the effects of any

any particular kind of matter, acting on the bodies either by impulſion or preſſure.

All that can be done here is to claſs the phenomena in the moſt diſtinct manner, according to their generality. In this we obtain a two-fold advantage. We may take it for granted that the moſt general phenomenon is the neareſt allied to the general cauſe. But, farther, we obtain by this method a true theory of all the ſubordinate phenomena. For a juſt theory is only the pointing out the general fact of which the phenomenon under conſideration is a particular inſtance. Beginning therefore with the phenomenon which comprehends all the particular caſes, we explain thoſe caſes in ſhewing *in what manner* they are included in the general phenomenon, and thus we ſhall be able to predict what will be the reſult of putting the body under conſideration into any particular ſituation. And perhaps we may find, in them all, coincidences which will enable us to ſhew that they are all modifications of a fact ſtill more general. If we gain this point, we ſhall have eſtabliſhed a complete theory of them, having diſcovered the general fact in which they are all comprehended. Should we for ever remain ignorant of the cauſe of this general fact, we have nevertheleſs rendered this a complete branch of mechanical theory. Nay, we may perhaps diſcover ſuch circumſtances of reſemblance between this general fact and others, with which we are better acquainted, that we ſhall, with great probability at leaſt, be able to aſſign the cauſe of the general fact itſelf, by ſhewing the law of which it is a particular inſtance.

We ſhall attempt this method on the preſent occaſion.

5 First leading fact. Iron arranges itſelf in a particular poſition.

The leading facts in magnetiſm are the two following:

1. If any oblong piece of iron, ſuch as a bar, rod, or wire, be ſo fitted, that it can aſſume any direction, it will arrange itſelf in a certain determinate direction with reſpect to the axis of the earth. Thus, if, in any part of Briton, an iron or ſteel wire be thruſt through a piece of cork, as repreſented in fig. 1. ſo as that the whole may ſwim level in water, and if it be laid in the water nearly north-weſt and ſouth eaſt, it will ſlowly change its poſition, and finally ſettle in a direction, making an angle of about 25 degrees with the meridian. (Plate XXXIV.)

This experiment, which we owe to Dr Gilbert (ſee B. I. ch. 11.), is delicate, and requires attention to many circumſtances. The force with which the iron tends toward this final poſition is extremely weak, and will be balanced by very minute and otherwiſe inſenſible reſiſtances; but we have never found it fail when executed as here directed. An iron wire of the ſize of an ordinary quill, and about eight or ten inches long, is very fit for the purpoſe. It ſhould be thruſt through the cork at right angles to its axis; and ſo adjuſted, by repeated trials, as to ſwim level or parallel to the horizon. The experiment muſt alſo be made at a great diſtance from all iron; therefore in a baſon of ſome other metal or earthen ware. It may ſometimes require a very long while before the motion begin; and if the wire has been placed at right angles to the direction which we have mentioned as final, it will never change its poſition: therefore we have directed it to be laid in a direction not too remote, yet very ſenſibly different from the final direction.

But this is not the true poſition affected by the iron rod. If it be thruſt through a piece of wood or cork perfectly ſpherical, in ſuch a manner that it paſſes thro' its centre, and if the centre of gravity coincide with this centre, and the whole be of ſuch weight as to remain in any part of the water without either aſcending or deſcending, then it will finally ſettle in a plane inclined to the meridian about 25°, and the north end will be depreſſed about 73° below the horizon.

All this is equivalent with ſaying, that if any oblong piece of iron or ſteel be very nicely poiſed on its centre of gravity, and at perfect liberty to turn round that centre in every direction, it will finally take the poſition now mentioned.

We have farther to obſerve with regard to this experiment, that it is indifferent which end of the rod be placed toward the north in the beginning of the experiment. That end will finally ſettle toward the north; and if the experiment be repeated with the ſame rod, but with the other end north, it will finally ſettle in this new attitude. It is, however, not always that we find pieces of iron thus perfectly indifferent. Very frequently one end affects the northerly poſition, and we cannot make the other end aſſume its place: the cauſes of this difference will be clearly ſeen by and bye.

6 Magnetical poſition.

The poſition thus affected by a rod of iron is called by Dr Gilbert the MAGNETICAL POSITION or DIRECTION. It is not the ſame, nor parallel in all parts of the earth, as will be more particularly noticed afterwards.

7 Second fact. Iron attracts and repels iron.

2. The other leading facts is this: When a piece of iron, lying in the *magnetical* poſition, or nearly ſo, and at perfect liberty to move in every direction, is approached by another oblong piece of iron, held nearly in the ſame poſition, it is attracted by it; that is, the moveable piece of iron will gradually approach to the one that is preſented to it, and will at laſt come into contact with it, and may then be ſlowly drawn along by it.

This phenomenon, although not ſo delicate as the former, is ſtill very nice, becauſe the attraction is ſo weak that it is balanced by almoſt inſenſible obſtructions. But the experiment will ſcarcely fail if conducted as follows: Let a ſtrong iron wire be made to float on water by means of a piece of cork, in the manner already deſcribed, having one end under water. See fig. 1. B.

When it is nearly in the magnetical poſition, bring the end of a pretty big iron rod, ſuch as the point of a new poker, within a quarter of an inch of its ſouthern end (holding the poker in a poſition not very different from the magnetical poſition), and hold it there for ſome time, not exactly ſouthward from it, but a little to one ſide. The floating iron will be obſerved to turn towards it with an accelerated motion; will touch it, and may then be drawn by it through the water in any direction. We ſhall have the ſame reſult by approaching the northern extremity of the floating iron with the upper end of the poker.

The ſame phenomenon may be obſerved by ſuſpending the firſt piece of iron by its middle by a long and ſlender hair or thread. The ſuſpenſion muſt be long, otherwiſe the ſtiffneſs of the hair or thread may be ſufficient for balancing the very ſmall force with which the pieces of iron tend toward each other. The phenomenon

non may alfo be obferved in a piece of iron which turns freely on a fine point, like the needle of the mariner's compafs.

In this, as in the former experiment, the ends of the pieces of iron are obferved, in general, to be indifferent; that is, either end of the one will attract either end of the other. It often happens, however, that the ends are not thus indifferent, and that the end of the moveable piece of iron, inftead of approaching the other, will be obferved to recede from it, and appear to avoid it. We fhall foon learn the caufe of this difference in the ftates of iron.

8
This action mutual.

It is fcarcely neceffary to remark, that we muft infer from thefe experiments, that the action is mutual between the two pieces of iron. Either of them may be the moveable piece which approaches the other, manifefting the attraction of that other. This reciprocity of action will be abundantly verified and explained in its proper place.

9
Not peculiar to magnets or loadftone;

Thefe two facts were long thought to be peculiar to loadftones and artificial magnets, that is, pieces of iron which have acquired this property by certain treatment with loadftones; but they were difcovered by Dr Gilbert to be inherent in all iron in its metallic ftate; and were thought by him to be neceffary confequences of a general principle in the conftitution of this globe. Thefe phenomena are indeed much more confpicuous in loadftones and magnets; and it is therefore with fuch that experiments are beft made for learning their various modifications.

10
But, in iron, is indifferent, and momentary, and in loadftones it is fixed and determinate.

But there is another circumftance, befides the degree of vivacity, in which the magnetifm of common iron and fteel remarkably differs from that of a loadftone or magnet. When a loadftone or magnet is fo fupported as to be at liberty to take any pofition, it arranges itfelf in the magnetical direction, and *one determined end* of it fettles in the northern quarter; and if it be placed fo that the other end is in that fituation, it does not remain there, but gradually turns round, and, after a few ofcillations, the *fame end* ultimately fettles in the north. This is diftinctly feen in the needle of the mariner's compafs, which is juft a fmall magnet prepared in the fame way with all other magnets. The feveral ends of loadftones or magnets are thus permanently the north or the fouth ends; whereas we faid that either end of a piece of common iron being turned to the northern quarter, it finally fettles there.

It is this circumftance which has rendered magnetifm fo precious a difcovery to mankind, by furnifhing us with the compafs, an inftrument by which we learn the different quarters of the horizon, and which thus tells the direction of a fhip's courfe through the pathlefs ocean (fee COMPASS and VARIATION, *Encycl.*); and alfo fhews us the directions of the veins and workings in the deepeft mines. It was natural therefore to call thofe the north and fouth ends of the mariner's needle, or of a loadftone or magnet. Dr Gilbert called them the POLES of the loadftone or magnet. He had found it convenient for the propofed train of his experiments to form his loadftones into fpheres, which he called TERRELLÆ, from their refemblance to this globe; in which cafe the north and fouth ends of his loadftones were the poles of the terrellæ. He therefore gave the name *pole* to that part of any loadftone or magnet which thus turned to the north or fouth. The denomination was adopted by all fubfequent writers, and now makes a term in the language of magnetifm.

Alfo, when we approach either end of a piece of iron A to either end of another B, thefe ends mutually attract; or if either end of a magnet A be brought near either end of a piece of common iron, they mutually attract each other. But if we bring that end of a magnet A which turns to the north near to the *fimilar* end of another magnet B, thefe ends will not attract each other, but, on the contrary, will repel. If the two magnets are made to float on pieces of wood, and have their north poles fronting each other, the magnets will retire from each other; and in doing fo, they generally turn round their axis, till the north pole of one front the fouth pole of the other, and then they run together. This is a very notable diftinction between the magnetifm of magnets and that of common iron; and whenever we fee a piece of iron fhew this permanent diftinction of its ends, we muft confider it as a magnet, and conclude that it has met with fome peculiar treatment.

It is not, however, ftrictly true, that the poles of loadftones or magnets are fo fixed in particular parts of their fubftance, nor that the poles of the fame name fo conftantly repel each other; for if a fmall or weak magnet A have its pole brought near the fimilar pole of a large or ftrong magnet B, they are often found to attract when almoft touching, although at more confiderable diftances they repel each other. But this is not an exception to the general propofition; for when the north pole of A is thus attracted by the north pole of B, it will be found by other trials to have all the qualities of a fouth pole, while thus in the neighbourhood of the north pole of B.

The magnetic properties and phenomena are conveniently diftinguifhed into thofe of FORCE and of POLARITY. Thofe of the firft clafs only were known to the ancients, and even of them their knowledge was extremely fcanty and imperfect. They may all be claffed under the following general propofitions. 12 Magnetic FORCE and POLARITY

1. The fimilar poles of two magnets repel each other with a force decreafing as the diftances increafe. 13 Similar poles repel, and diffimilar poles attract, each other.

2. The diffimilar poles of two magnets attract each other with a force decreafing as the diftances increafe.

3. Magnets arrange themfelves in a certain determinate pofition with refpect to each other.

14
The law of attraction and repulfion is of difficult inveftigation.

The firft object of refearch in our further examination of thefe properties is the relation which is obferved to obtain between the diftances of the acting poles and their force of action. This has accordingly occupied much attention of the philofophers, and numberlefs experiments have been made in order to afcertain the law of variation, both of the attraction and the repulfion. A great number of thefe have been narrated in the article MAGNETISM of the *Encycl.* from which it appears that it has been a matter of great difficulty, and had not been afcertained with certainty or precifion when that article was publifhed. It is obvious, from the nature of the thing, that the determination is very difficult, and the inveftigation very complicated. We can only obferve the fimultaneous motion of the whole magnet; yet we know that there are four feparate actions coexifting and contributing in different directions, and with different forces, to the fenfible effect. The force which we meafure, in any way whatever, is compounded

-pounded of four different forces, which we cannot feparate and meafure apart; for the north pole of A repels the north pole of B, and attracts its fouth pole, while the fouth pole of A exerts the oppofite forces on the fame poles of B. The attraction which we obferve is the excefs of two unequal attractions above two unequal repulfions. The fame might be faid of an obferved repulfion. Nay, the matter is incomparably more complicated than this; becaufe, for any thing that we know, *every* particle of A acts on *every* particle of B, and is acted on by it; and the intenfity of thofe actions may be different at the fame diftances, and is certainly different when the diftances are fo. Thus there is a combination of an unknown number of actions, each of which is unknown individually, both in direction and intenfity. The precife determination is therefore, in all probability, impoffible. By precife determination, we mean the law of mutual action between two magnetic particles, or that precife function of the diftance which defines the intenfity of the force; fo that meafuring the diftance of the acting particles on the axis of a curve, the ordinates of the curve may have the proportions of the attractions and repulfions.

It is almoft needlefs to attempt any deduction of the law of variation from the numerous experiments which have been publifhed by different philofophers. An ample collection of them may be feen in Scarella's treatife. Mr Mufchenbroek has made a prodigious number; but all are fo anomalous, and exhibit fuch different laws of diminution by an increafe of diftance, that we may be certain that the experiments have been injudicious. Attention has not been paid to the proper objects. Magnets of moft improper fhapes have been employed, and of moft diffufe polarity. No notice has been taken of a circumftance which, one fhould think, ought to have occupied the chief attention; namely, the joint action of four poles, of which the experiment exhibits only the complex refult. A very flight reflection might have made the enquirer perceive, that the attractions or repulfions are not the moft proper phenomena for declaring the precife law of variation; becaufe what we obferve is only the excefs of a fmall difference of attractions and repulfions above another fmall difference. Mr Hawkfbee and Dr Brook Taylor employed a much better method, by obferving the deviations from the meridian which a magnet occafioned in a compafs needle at different diftances. This is occafioned by the difference of the two fums of the fame forces; and this difference may be made a hundred times greater than the other. But they employed magnets of moft improper fhapes.

15 Judicious experiments by Mr Lambert.

We muft except from this criticifm the experiments of Mr Lambert, recorded in the Memoirs of the Academy of Berlin for 1756, publifhed in 1758. This moft fagacious philofopher (for he highly merits that name) placed a mariner's needle at various diftances from a magnet, in the direction of its axis, and obferved the declination from the magnetic meridian produced by the magnet, and the obliquity of the magnet to the axis of the needle. Thus was the action of the magnet fet in oppofition and equilibrium with the natural polarity of the needle. But the difficulty was to difcover in what proportion each of thefe forces was changed by their obliquity of action on this little lever. No man excelled Mr Lambert in addrefs in devifing methods of mathematical inveftigation. He obferved, that when the obliquity of the magnet to the axis of the needle was 30°, it caufed it to decline 15°. When the obliquity was 75°, the diftance being the fame, it declined 30°. Call the obliquity o, and the declination d, and let f be that function of the angle which is proportionable to the action. Alfo let p be the natural polarity of the needle, and m the force of the magnet. It is evident that

$$p \times f,\ 15 = m \times f,\ 30$$

And $p : m = f,\ 30 : f,\ 15$; for the fame reafon

$$p : m = f,\ 75 : f,\ 30$$

Therefore $f,\ 15 : f\ 30 = f,\ 30 : f,\ 75°$.

But it is well known that

Sine 15 : Sine 30 = Sine 30 : Sine 75.

Hence Mr Lambert was led to conjecture, that the fine was that function of the angle which was proportional to the action of magnetifm on a lever. But one experiment was infufficient for determining this point. He made a fimilar comparifon of feveral other obliquities and declinations with the fame diftances of the magnet, and alfo with other diftances; and he put it paft all difpute, that his conjecture was juft.

Had Mr Lambert's experiments terminated here, it muft be granted that he has made a notable difcovery in the theory of the intimate nature of magnetifm. It completely refutes all the theories which pretend to explain the action of the magnet by the impulfion of a ftream of fluid, or by preffure arifing from the motion of fuch a ftream; for in this cafe the preffure on the needle muft have diminifhed in the duplicate ratio of the fine. The directive power with the angle 90 muft be 4 times greater than with the angle 30°; whereas it was obferved to be only twice as great. Magnetifm does not act therefore by the impulfion or preffure of a ftream of fluid, but in the manner of a fimple incitement, as we conceive attraction or repulfion to act.

Having afcertained the effect of obliquity, Mr Lambert proceeded to examine the effect of diftance; and, by a moft ingenious analyfis of his obfervations, he difcovered, that if we reprefent the force of the magnet by f, and the diftance of the neareft pole of the magnet from the centre of the needle by δ, and if a be a conftant quantity, nearly equal to two-thirds of the length of the needle, we have f proportional to $\overline{\delta - a^2}$.

Mr Lambert found this hold with very great exactnefs with magnets ten times larger, and needles twice as fhort. But he acknowledges, that it gives a very fingular refult, as if the action of a magnet were exerted from a centre beyond itfelf. He attributes this to its true caufe, the ftill great complication of the refult, arifing from the action of the remote pole of the magnet. He therefore takes another method of examination, which we fhall underftand by and bye, when we confider the *directive* power of a magnet. We have mentioned this imperfect attempt chiefly on account of the unqueftionable manner in which he has afcertained the effect of obliquity, and the importance of this determination.

We have attempted this inveftigation in a very fimple manner. We got fome magnets made, confifting of two balls connected by a flender rod. By a very particular mode of impregnation, we gave them a pretty good

 magnet-

magnetifm ; and the force of each pole feemed to refide almoft in the centre of the ball. This was our object in giving them this fhape. It reduced the examination both of the attractive and of the directive power to a very eafy computation. The refult was, that the force of each pole varied in the inverfe duplicate ratio of the diftance The error of this hypothefis in no cafe amounted to $\frac{1}{17}$th of the whole. In computing for the phenomena of the directive power, the irregularities and deviations from this ratio were much fmaller.

The previous knowledge of this function would greatly expedite and facilitate our farther inveftigation ; but we muft content ourfelves with a very imperfect approximation, and with arriving at the defired determination by degrees, and by a very circuitous route.

16 Attempt to explain the phenomena without a precife knowledge of this law.

It is a matter of experience, that when two magnets are taken, each of which is as nearly equal as poffible in the ftrength of both poles, then, if they are placed with their axes in one ftraight line, and the north pole of one fronting the fouth pole of the other, they attract each other with a force which diminifhes as the diftance increafes ; and this variation of force is regular, that is, without any fudden changes of intenfity, till it becomes infenfible. No inftance has occurred of its breaking fuddenly off when of any fenfible force, but it appears to diminifh continually like gravity. No inftance occurs in which attraction is changed into repulfion.

But it is, moreover, to be particularly remarked, that, having made this obfervation with the north pole of A fronting the fouth pole of B, if the experiment be repeated with the fouth pole of A fronting the north pole of B, the refults will be precifely the fame. And, laftly, it is a matter of unexcepted experience, that the fenfible action of A on B, meafured by the force which is neceffary for preventing the farther approach of B, is precifely equal to the action of B on A. This is the cafe, however unequal the force of the two magnets may be ; that is, although A may fupport ten pounds of iron, and B only ten ounces.

Now, the fimpleft view we can take of this experiment is, by fuppofing the whole action of one end or pole of a magnet to be exerted at one point of it. This will give us four actions of A on B, accompanied by as many equal and oppofite actions of B on A. It is plain that we may content ourfelves with the inveftigation of one only of thefe fets of actions.

What we obferve is the excefs of the attractions of the poles of A for the diffimilar poles of B above the repulfions of the fame poles of A for the fimilar poles of B. At all diftances there is fuch an excefs. The fum of the attractions exceeds the fum of the repulfions competent to every diftance.

Now this will really happen, if we fuppofe that the poles of a magnet are of equal ftrength, and that, however thefe different magnets differ in ftrength, they have the fame law of diminution by an increafe of diftance. The firft circumftance is a very poffible thing, and the laft is demonftrated by the obferved equality of action and reaction. Every thing will now appear very plain, by reprefenting (as we did in Electricity, *Suppl.* n° 44, &c.) the intenfities of attraction and repulfion by the ordinates of a curve, of which the abfciffæ reprefent the diftances of the acting poles.

Therefore let A and B (fig. 2.) reprefent the two magnets, placed with their four poles S, N, s, n, in a ftraight line. In the ftraight line O q take O m, O p, O n, O q, refpectively equal to N s, N n, S s, S n ; and let MPNQ be a curve line, having O q for its axis and affymptote ; and let the curve, in every part, be convex towards its axis. Then draw the ordinates m M, p P, n N, q Q, to the curve. Thefe ordinates will reprefent the intenfities of the forces exerted between the poles of the magnets, in fuch a manner as to fulfil all the conditions that are really obferved : For m M reprefents the attraction of the north pole N of the magnet, A for the fouth pole s of the magnet B ; p P reprefents the repulfion of N for n ; n N reprefents the repulfion of S for s ; and q Q reprefents the attraction of S for n. The diftance between m and n, or between p and q, is equal to the length of the magnet A, and m p, or n q, is equal to that of B. M m, P p, and N n, Q q, are pairs of equidiftant ordinates. It furely requires only the infpection of the figure to fee that, in whatever fituation along the axis we place thofe pairs of equidiftant ordinates, the fum of M m and Q q will always exceed the fum of P p and N n ; that is, the fum of the attractions will always exceed that of the repulfions. This will not be the cafe if the curve, whofe ordinates are proportional to the forces, have a point Z of contrary flexure, as is reprefented by the dotted curve P′ZQ′. For this curve, having O q for its affymptote (in order to correfpond with forces which diminifh continually by an increafe of diftance, but do not abruptly ceafe (muft have its convexity turned toward this affymptote in the remote parts. But there will be an arch MPZ between Z and O, which is concave toward the affymptote. In which cafe, it is impoffible that M m + Q q fhall be lefs than P p + N n ; and then the repulfions will exceed the attractions; which is contrary to the whole train of obfervation.

It may be thought, that if the repulfion exerted between two particles be always lefs than the attraction at the fame diftance, the phenomena will be accounted for, although the law of action be not reprefented by fuch a curve as has been affumed. Undoubtedly they will, while the diffimilar poles form each other. But the refults of fuch a fuppofition will not agree with the phenomena while the fimilar poles front each other : For it is an uncontradicted fact, that when two fine hard magnets, whofe poles are nearly or exactly of equal vigour, have their fimilar poles fronting each other, the repulfions fall very little fhort of the attractions at the fame diftances when their pofition is changed: When the diftances are confiderable, fcarcely any difference can be obferved in the beginning of the experiment. The differences, alfo, which are obferved at fmaller diftances, are obferved to augment by continuing the magnets in their places without changing their diftances ; and therefore feem to arife from fome change produced by each on the magnetifm of the other. And, accordingly, if we invert one of the magnets, we fhall find that the attractions have been diminifhed as much as the repulfions. Now, the confequences of magnetic repulfion, being always weaker than attraction, would be the reverfe of this. The differences would appear moft remarkable in the greater diftances, and magnets might be found which repel at fmall diftances, and attract at greater diftances ; which is contrary to all obfervation.

From all this it follows, with fufficient evidence for our

our prefent purpofe, that the function of the diftance which expreffes the law of magnetic action muft be reprefented by the ordinates of a curve of the hyperbolic kind, referred to its affymptote as an axis; and therefore always convex toward this axis. We think it alfo fufficiently clear, that the confequences which we have deduced from the fimple fuppofition of four acting points, inftead of the combined action of every particle, may be adopted with fafety. For they would be juft, if there were only thofe four particles; they would be juft with refpect to another four particles—therefore they would be juft when thefe are joined; and fo on of any number. Therefore the curve, whofe ordinates exprefs the mean action of each pole, as if exerted by its centre of effort, will have the fame general form: It will be convex toward its affymptotic axis.

It will greatly aid our conceptions of the combined actions of the four magnetic poles, if we notice fome of the primary properties of a curve of this kind, limited by no other condition.

17 Unquestionable inferences from the phenomena.

Draw the chords MQ, PN, MP, NQ. Bifect them in B, D, E, F, and join EF. Draw the ordinates E e Ff, and BDb (cutting EF in C. Draw P u parallel to the axis, cutting E e in ι. Draw alfo Q i parallel to the axis, cutting Ff in τ. Alfo draw FHL parallel to the axis, and P o t parallel to QN; and draw PL l, and P e x, cutting M m in l and x.

Let each ordinate be reprefented by the letter at its interfection with the axis. Thus, the ordinates M m and Q q may be reprefented by m and q, &c.

Becaufe MP is bifected in E, M t is double of E ι; M l is double of EL; M x is double of E e. Alfo, becaufe P t is parallel to QN, and P u to Q i, we have $t\,u = N\,i$. From thefe premifes, it is eafy to perceive, that,

1. $Bb = \frac{m+q}{2}$.
2. $Db = \frac{p+n}{2}$.
3. $BD = \frac{\overline{m+q}-\overline{p+n}}{2}$.
4. $Mu = m-p$.
5. $ut = n-q$.
6. $Mt = \overline{m-p}-\overline{n-q}$.
7. $Ee = \frac{m+p}{2}$.
8. $Ff = \frac{n+q}{2}$.
9. $Ml = \overline{m+p}-\overline{n+q}$.
10. $EL = \frac{\overline{m+p}-\overline{n+q}}{2}$.
11. $CD = \frac{\overline{m+q}-\overline{p+n}}{4}$.
12. $CH = \frac{\overline{m+p}-\overline{n+q}}{4}$.

Thefe combinations will fuggeft to the attentive reader the explanation of many modifications of the combined action of the four poles of two magnets. They are all comprehended in one propofition, which it will be convenient to render familiar to the thought; namely, if two pairs of equidiftant ordinates be taken, the fum of the two extremes exceeds that of the intermediate ones. $m+q$ is greater than $p+n$. Alfo, the difference between the pair neareft to O exceeds the difference between the remote pair.

Now, conceiving thefe ordinates to reprefent the mutual actions of the magnetic poles, we fee that their tendency to or from each other, or their fenfible attractions or repulfions, are expreffed by $\overline{m+q}-\overline{n+p}$; that is, by the excefs of the fum of the actions of the neareft and moft remote poles above the fum of the actions of the intermediate diftant poles. It will alfo be frequently convenient to confider this tendency as reprefented by $\overline{m-p}-\overline{n-q}$; that is, by the excefs of the difference of the actions of the neareft pole of A on the two poles of B, above the difference of the actions of its remote pole on the fame poles of B.

Let us now confider fome of the chief modifications of thefe actions.

1. Let the diffimilar poles front each other. It is plain that $m+q$ reprefent attractions, and that $p+n$ reprefent repulfions. Alfo $m+q$ is greater than $p+n$. Therefore the magnets will attract each other. This attraction is alfo reprefented by $\overline{m-p}-\overline{n-q}$. 18 Explanation of the observed attraction of magnets,

Now $m+q-p+n$ is evidently equal to M t, or to twice E o, or to twice BD, or to four times CD.

This action will be increafed,

1. By increafing the ftrength of either of the magnets. The action of the magnets is the combined action of each acting particle of the one on each acting particle of the other; and it is mutual. Therefore all the ordinates will increafe in the ratio of the ftrength of each magnet, and their fums and differences will increafe in the fame ratio.

2. By diminifhing the diftance between the magnets. For this brings all the ordinates nearer to O, while their diftance mp, pn, nq, remain as before. In this cafe it is plain that M u, the difference of M m and Pp, will increafe fafter than $t\,u$ or N i, the difference between N n and Q q. Therefore M t will increafe; that is, the attraction will increafe.

3. By increafing the length of A, while the diftance between them remains the fame. For O m remaining the fame, as alfo mp and nq, while nq is only removed farther from mp, it is plain M u remains the fame, and that N i and $t\,u$ are diminifhed; therefore M t muft increafe, or the attraction muft increafe.

4. By increafing the length of B, the diftance between them remaining the fame. For this increafes mp and nq; and confequently increafes M u and $t\,u$. But M u increafes more than $t\,u$; and therefore M t is increafed, and the attraction or tendency is increafed.

All thefe confequences of our original fuppofition, that the magnetic action may be reprefented by the ordinates of a curve every where convex to an affymptotic axis, are ftrictly conformable to obfervation.

19 And of their repulfions.

If we place the magnets with their fimilar poles fronting each other, it is evident that the ordinates which expreffed attractions in the former cafe, will now exprefs repulfions; and that the forces with which the magnets now repel each other, are equal to thofe with which they attracted when at the fame diftances. When the experiments are made with good loadftones, or very fine magnets, tempered extremely hard, and having the energy of their poles fenfibly refiding in a fmall fpace very near the extremities, the refults are alfo very nearly ly conformable to this mathematical theory; but there is generally a weaker action. The magnets ſeldom repel as ſtrongly as they attract at the ſame diſtance; at leaſt when theſe diſtances are ſmall. If one or both of the magnets is ſoft, or if one of them be much more vigorous than the other, there are obſerved much greater deviations from this theory. The repulſions are *conſiderably* weaker than the attractions at the ſame diſtance, and the law of variation becomes extremely different. When placed at very conſiderable diſtances, they repel. As the magnet B is brought nearer to A, the repulſion increaſes, agreeable to the theory, but not ſo faſt. Bringing them ſtill nearer, the repulſion ceaſes to increaſe, then gradually diminiſhes, and frequently vaniſhes altogether, before the magnets are in contact; and when brought ſtill nearer, it is changed into attraction.

20 Seeming exceptions obviated. But more careful obſervation ſhews, that this anomaly does not invalidate the theory. It is found that the vigour of the magnet is permanently changed by this proceſs. The magnets act on each other in ſuch a way as to weaken each other's magnetiſm. Nay, it frequently happens, that the weaker or the ſofter of the two has had its magnetiſm changed, and that the pole neareſt to the other has changed its nature. While they are lying in contact, or at ſuch a diſtance that they attract, although their ſimilar poles front each other, it is found that the pole of one of them is really changed; although it may ſometimes recover its former ſpecies again, but never ſo vigorouſly as when the other magnet is removed. In ſhort, it is obſerved, that the magnetiſm is diminiſhed in all experiments in which the magnets repel each other, and that it is improved in all experiments in which they attract.

We have hitherto ſuppoſed the magnets placed with their axes in one ſtraight line. If they are differently placed, we cannot aſcertain by this ſingle circumſtance of the law of magnetic action, whether they will attract or repel—we muſt know ſomewhat more of the variation of force by a change of diſtance.

21 Directive power explained. If the magnet B be not at liberty to approach toward A, or recede from it, but be ſo ſupported at its centre B that it can turn round it, it is very plain that it will retain the poſition in which it is drawn in the figure. For its ſouth pole s being more attracted by N than it is repelled by S, is, on the whole, attracted by the magnet A; and, by this attraction, it would vibrate like a pendulum that is ſupported at the centre B. In like manner, its north pole n is more repelled by N than it is attracted by S, and is, on the whole, repelled. The part Bn would therefore alſo vibrate like a pendulum round B. Thus each half of it is urged into the very poſition which it now has; and if this poſition be deranged a little, the attraction of sB toward A, and the repulſion of nB from it, would impel it toward the poſition s B n.

This will be very evident, if we put the magnet B into the poſition s' B n' at right angles to the line AB. The pole s' and the pole n' are urged in oppoſite, and therefore conſpiring, directions with equal forces, very nearly at right angles to $n' s'$, if the magnet B be ſmall. In any oblique poſition, the forces will be ſomewhat unequal, and account muſt be had of the obliquity of the action, in order to know the preciſe rotative momentum of the actions.

Dr Gilbert has given to this modification of the action of A on B, the name of VIS DISPONENS; which we may tranſlate by DIRECTIVE POWER OR FORCE. Alſo, that modification of the tendency of B to or from A is called by him the VERTICITAS of B. We might call it the VERTICITY of B; but we think that the name POLARITY is ſufficiently expreſſive of the phenomenon; and as it has come into general uſe, we ſhall abide by it.

It is not ſo eaſy to give a general, and at the ſame time preciſe, meaſure of the directive power of A and polarity of B. 22 Its meaſure. The magnet B muſt be conſidered as a lever; and then the force tending to bring it into its ultimate poſition $n s$ depends both on the diſtance of its poles from N and S, and alſo on the angle which the axis of B makes with the line AB. When the axis of B coincides with AB, the force acting on its poles, tending to *keep* them in that ſituation, is evidently $\overline{m+p} - \overline{n+q}$, and therefore may be repreſented by M l (in fig. 2.), or by twice EL, or by four times CH. If B has the poſition n'Bs', perpendicular to AB, let the ordinates E e and F f cut the curve on I and K; and draw KL parallel to the axis (our figure cauſes this line almoſt to coincide with QL, and in all important caſes it will be nearly the ſame). In this caſe IL will expreſs one half of this force. Either of theſe eſtimations of this modification of the mutual action of the magnets will be ſufficient for the objects we have in view.

The directive power of A, and the polarity of B, are increaſed, 23 How increaſed and diminiſhed

1. By increaſing the ſtrength of one or both of the magnets. This is evident,

2. By diminiſhing the diſtance of the magnets. For this, by increaſing the ſum of M m and P p more than the ſum of N n and Q q, muſt increaſe EL or M l.

3. By increaſing the length of A. For this, by removing n and q farther from m and p, muſt depreſs the points L and l, and increaſe EL, or IL, or M l.

4. By diminiſhing the length of B, while the diſtance N s between the magnets remains the ſame. For this, by bringing p and q nearer to m and n, muſt increaſe M m + P p more than N n + Q q. Or, by bringing E e and F f nearer to M m and N n, it muſt increaſe EL and M l.

If the diſtance N n between the pole of A and the remote pole of B remain the ſame, the directive force of A, and polarity of B, are diminiſhed by diminiſhing the length of B, as is eaſily ſeen from what has been juſt now ſaid. It is alſo diminiſhed, but in a very ſmall degree, by diminiſhing the length of B, when the diſtance between the centres of A and B remain the ſame. For, in this caſe, the ordinates I e and K f retain their places; but the points m and p approach to e; and this brings the interſection E of the ordinate and chord nearer to I, and diminiſhes EL, becauſe the point L is not ſo much depreſſed by the approach of F to K as E is depreſſed.

But in all caſes, the *ratio* of the directive power of A to its attractive force, or of the polarity of B to its tendency to A, is increaſed by diminiſhing the length of B. For it is plain that by diminiſhing $m p$ and $n q$, while I e and K f keep their places, the point o is raiſed, and the point L is depreſſed; and therefore the ratio of EL to E[illegible] or of M l to M t, is increaſed. We even ſee that, by diminiſhing the length of B continually 24 Circumſtances affecting the proportion of the attractive and directive powers.

and

and without end, the ratio of $M\,l$ to $M\,t$ may be made to exceed any ratio that can be assigned.

25 'he polarity of a nall magnet may be reat while he attraction is insensible.

Now, since diminishing the length of B increases the ratio of the directive power of A to its attractive power, while increasing the length of A increases both, and also increases the ratio of EL to E o (as is very easily seen), and since this increase may be as great as we please, it necessarily follows, that if the same very small magnet B be placed at such distances from a large and strong magnet A, and from a smaller and less vigorous one C, as to have equal polarities to both, its tendency to A will be less than its tendency to C. It may even be less in any ratio we please, by sufficiently diminishing the length of B.

Dr Gilbert observed this; and he expresses his observation by saying, that the directive power extends to greater distances than the attractive power. We must just conclude, that the last becomes *insensible* at smaller distances than the first. This will be found a very important observation. It may be of use to keep in mind, that the directive power of a magnet A on another magnet B, is the difference of the *sums* of the actions of each pole of A on both poles of B; and the attractive power of A for another magnet B, is the difference of the *differences* of these actions.

It may also be remarked just now, that the directive force of A always exceeds its attractive force by the quantity $2\ (p - q)$. For their difference may be expressed by $t\,l$, which is equal to twice o L. Now $\epsilon\,e$ is equal to $P\,p$, or to p; and ϵ L is equal to $P\,p - F\,f$, or to $P\,p - Q\,q - F\,\varphi$, or to $P\,p - Q\,q - o\,\epsilon$. Therefore $o\,L = P\,p - Q\,q$, and $t\,l = 2\,(P\,p - Q\,q)$, $= 2\ (p - q)$.

By inspecting this figure with attention, we obtain indications of many interesting particulars. If the lengths of the magnets A and B are the same, the point n in the axis of the curve will coincide with p. As the length of A increases, the part $n\,q$ is removed farther from the part $m\,p$. The line P t becomes less inclined to the axis, and is ultimately parallel to it, when n is infinitely remote. At this time L falls on e; so that the ultimate ratio of the attraction to the polarity is that of E ϵ to E e, when the magnet A is infinitely long. It is then the ratio of the difference of the actions of the nearest pole of A on the two poles of B to the sum of these actions. Hence it follows, that when A is very great and B very small, the polarity of B is vastly greater than its tendency to A. It may have a great polarity when its tendency is insensible.

The ratio of the polarity to the attraction also increases by increasing the distance of the magnets while their dimensions continue the same. This will appear, by remarking that the chords MP and NQ must intersect in some point ϖ; and that when the four points m, p, n, and q, move off from O, keeping the same distances from each other, E o will diminish faster than EL, and the ratio of EL to EO will continually increase.

Therefore when a small magnet B is placed at such a distance from a great magnet A, and from a smaller one C, as to have equal polarity to both, its tendency to C will exceed its tendency to A. For the polarities being equal, it must be farther from the great magnet; in which case the ratio of its polarity to its attraction is increased.

And this will also obtain if the magnets differ also in strength. For, to have equal polarities, B must be still farther from the great and powerful magnet.

For all these reasons, a large and powerful magnet may exert a strong directive power, while its attractive power is insensible.

We have hitherto supposed the magnet B to be placed in the direction of the axis of A, and only at liberty to turn round its centre B. But let its centre be placed on the centre of A, as in fig. 3. it must evidently take a position which may be called subcontrary to that of A, the north pole of B turning toward the south pole of A, and its south pole turning toward the north pole of A. 26 Peculiarities of oblique positions of two magnets.

The same thing must happen when the centre of B is placed in B, any where in the line AE perpendicular to NS. S attracts n with a force $n\,b$, while N repels n with a force $n\,o$, somewhat smaller than $n\,b$. These two compose the force $n\,d$. In like manner, the two forces $s\,e$ and $s\,f$, exerted by N and S on the pole s, compose the force $s\,q$. Now if the axis of the magnet B be parallel to NS, but the poles in a contrary position, and if each magnet be equally vigorous in both poles, the magnet B will retain this position; because the forces $n\,b$ and $s\,e$ are equal, as also the forces $n\,c$ and $s\,f$. These must compose two forces $n\,d$ and $s\,q$, which are equal, and equally inclined to $n\,s$; and they will therefore be in equilibrio on this lever.

Let us now place the centre of the small magnet in C, neither in the axis of the other, nor in the perpendicular AE. Let its north pole n point toward the centre of A. It cannot remain in this position; for N repels n with a force $n\,c$, while S attracts it with a force $n\,b$ (smaller than $n\,c$, because the distance is greater). These two compose a force $n\,d$ considerably different from the direction $c\,n$ of its axis. In like manner, the south pole s of the small magnet is acted on by two forces $s\,e$ and $s\,f$, exerted by the two poles of A, which compose a force $s\,q$ nearly equal and parallel to $n\,d$, but in a nearly opposite direction. It is plain that these forces must turn the small magnet round its centre C, and that it cannot rest but in a position nearly parallel to $n\,d$ or $s\,f$. Its position is better represented by fig. 4. with its south pole turned toward the north pole of the other magnet, and its north pole in the opposite direction.

What the precise position will be, depends on that function of the distance which is always proportional to the intensity of the action; on the force of each of the poles of A, and on the length of the magnet B. Nay, even when we know this function, the problem is still very intricate.

There are methods by which we may approximate to the function with success. If the magnet B be indefinitely small, so that we may consider the actions on its two poles as equal, the investigation is greatly simplified. For, in this case, each pole of the small magnet B (fig. 5.) may be conceived as coinciding with its centre. Then, drawing NB, SB, and taking B b toward N, to represent the force with which N attracts the south pole of B, and taking B c, in SB produced to represent the force with which S repels the same pole, the compound force acting on this pole is B d, the diagonal of a parallelogram B b, $d\,c$. In like manner, we must take B e, in N b produced, and equal to B b, to 27 Means of acquiring a [?] measure of the law of action.

to reprefent the repulfion of N for the north pole of B, and Bf equal to Bc, to reprefent the attraction of S for this pole. The compound force will be Bg, equal and oppofite to Bd. It follows evidently from this inveftigation, that the fmall magnet will not reft in any pofition but dg. In this fuppofition, therefore, of extreme minutenefs of the magnet B, one of the parallelograms is fufficient. We may farther remark, that we have this approximation fecure againft any error arifing from the fuppofition that all the action of each pole of B is exerted by one point. Although we fuppofe it diffufed over a confiderable portion of the magnet, ftill the extreme minutenefs of the whole makes the action, even on its extreme points, very nearly equal.

28 Law of action inveftigated—MAGNETIC CURVE.

Hence may be derived a conftruction for afcertaining the pofition of the needle, when the function m of the diftance is given, or for difcovering this function by obfervation of the pofition of the needle.

Let NS (fig. 5. n° 2.) meet the direction of the needle in K. Make BG = BN, and draw NF, GE, SH, perpendicular to BK. It is evident that Bb is to Bc, or bd, as the fine of the angle HBS to the fine of KBN. Therefore, becaufe BG and BN are equal, we have $Bb : Bc = GE : NF$.

$$\begin{array}{lll} \text{Therefore } GE : NF & = BS^m & : BN^m \\ \text{But} \quad SH : GE & = BS & : BN \\ \text{Therefore } SH : NF & = BS^{m+1} & : BN^{m+1} \\ \text{And} \quad SK : NK & = BS^{m+1} & : BN^{m+1}. \end{array}$$

If magnetic action be inverfely as the diftance, we have $SK : NK = BS^2 : BN^2$, and B is in the circumference of a circle which paffes through S and N, and has BK for a tangent, as is plain by elementary geometry. If the action be inverfely as the fquare of the diftance, we have $SK : NK = BS^3 : BN^3$, and B is in the circumference of a curve of more difficult inveftigation. But, as in the circle, the fum of the angles BSN and BNS is a conftant angle; fo, in this curve, the fum of the cofines of thofe angles is a conftant quantity. This fuggefts a very fimple conftruction of the curve. Let it pafs through the point T of the line AT, drawn from the centre of the magnet, perpendicular to its axis. Defcribe the femicircle SPQN, cutting ST and NT in P and Q. Then, in order to find the point where any line SB cuts the curve, let it cut the femicircle in p, and apply the line $Nq = SP + NQ - Sp$, and produce it till it meet the line SB in B, which is a point in the curve; for it is evident that Sp and Nq are the cofines of BSN and BNS. We hope to give, by the help of a learned friend, the complete conftruction of curves for every value of m, in an Appendix to this article. It will form a new and curious clafs, arranged by the functions of the angles at N and S.

But, in the mean time, we have determined the pofition of an indefinitely fmall needle, in refpect of a magnet of which we may conceive the polar activity concentrated in two points; and we may, on the other hand, make ufe of the obferved pofitions of fuch a needle and magnet for difcovering the value of m. For, fince $\frac{SK}{NK} = \frac{SB^{m+1}}{NB^{m+1}}$, it is plain that $m = \frac{\text{Log. } SK : NK}{\text{Log. } SB : NB} - 1$. Thus, in an obfervation which the writer of this article made on a very fmall needle, and a magnet having globular poles, and $8\frac{1}{8}$ inches between their centres, he found $SB = 5\frac{1}{3}$, $NB = \frac{1}{3}$, $SK = 11,49$, and $NK = 3,37$. This gives $m = 1,97$, which differs from 2 only $\frac{1}{60}$th part. Finding it fo very near the inverfe duplicate ratio of the diftance, a circle VUZ was defcribed, the circumference of which is the locus of $SB : BN = 8 : 5,333$. When the centre of the needle was placed anywhere in the circumference of this circle, it fcarcely deviated from the point K, except when fo far removed from the magnet that its natural polarity prevailed over the directive power of the magnet, or fo near its middle that the action of the cylindrical part became very fenfible.

It is plain that the length of the needle muft occafion fome deviation from the magnetic direction, by deftroying the perfect equality of action on its two poles. He therefore employed three needles of $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$ of an inch in length; and by noticing the differences of direction, he inferred what would be the direction, if the forces on each pole were precifely equal. He had the pleafure of feeing that the deviation from the inverfe duplicate ratio of the diftances was fcarcely perceptible.

Mr Lambert's experiments on the directive power of the magnet, narrated in his fecond differtation in the 22d volume of the memoirs of the Academy of Berlin, are the moft valuable of all that are on record; and the ingenious addrefs with which they are conducted, and the inferences are drawn, would have done credit to Newton himfelf. We earneftly recommend the careful perufal of that Effay, as the moft inftructive of any that we have read. The writer of this found himfelf obliged to repeat all his former experiments, mentioned above, in Mr Lambert's manner, and with his precaution of keeping the needle in its natural pofition; a circumftance to which he had not fufficiently attended before. The new refults were ftill more conformable to his conjecture as to the law of variation. Mr Lambert clofes his differtation with an hypothefis, " that the force of each tranfverfe element of a magnet is as its diftance from the centre, and its action on a particle of another magnet is inverfely as the fquare of the diftance." On this fuppofition, he calculates the pofition of a very fmall needle, and draws three of the curves to which it fhould be the tangent. Thefe are very exactly coincident with fome that he obferved. We tried this with feveral magnetic bars, and found it very conformable to obfervation in fome magnets; but deviating fo far in the cafe of other magnets, that we are convinced that there is no rule for the force of each tranfverfe element of a magnet, and that the magnetifm is differently difpofed in different magnets. It was chiefly this which induced us to form the magnets employed in this refearch of two balls united by a flender rod. Lichtenberg, in his notes on Erxleben's Natural Philofophy, fays, that there is a MS of the celebrated Tobias Mayer in the library of the Academy of Gottingen, in which he affumes the hypothefis above mentioned, and gives a conftruction of the magnetic curves founded on it, making them a kind of catenaria. The interior curves do indeed refemble the catenaria, but the exterior are totally unlike. But there is no occafion for much argument to convince us, that the firft part of this hypothefis is not only gratuitous, but unwarranted by any general phenomena. We know that a magnetical bar may have its magnetifm very differently difpofed; for it may have more than two poles, and the intermediate poles *cannot* have this difpofition of the magnetifm.

netifm. Such a difpofition is perhaps poffible; but is by no means general, or even frequent. We are difpofed to think, that permanent magnetifm muft have its intenfity diminifhing in the very extremity of the bar. The reader may guefs at our reafons from what is faid in ELECTRICITY, *Suppl.* n° 222.

29 PRIMARY and SECONDARY, or SIMPLE and COMPOUND curves.

The following very curious and inftructive phenomenon was the firft thing which greatly excited the curiofity of the writer of this article, and long puzzled him to explain it. Indeed it was his endeavours to explain it which gradually opened up to him the theory of the mutual action of magnets contained in thefe paragraphs, and firft gave him occafion to admire the fagacity of Dr Gilbert, and to fee the connecting principle of the vaft variety of obfervations and experiments which that philofopher had made. It feems owing to the want of this connecting principle, that a book fo rich in facts fhould be fo little read, and that fo many of Dr Gilbert's obfervations have been publifhed by others as new difcoveries.

Amufing himfelf in the fummer 1758 with magnetic experiments, two large and ftrong magnets A and B (fig. 6), were placed with their diffimilar poles fronting each other, and about three inches apart. A fmall needle, fupported on a point, was placed between them at D, and it arranged itfelf in the fame manner as the great magnets. Happening to fet it off to a good diftance on the table, as at F, he was furprifed to fee it immediately turn round on its pivot, and arrange itfelf nearly in the oppofite direction. Bringing it back to D reftored it to its former pofition. Carrying it gradually out along DF, perpendicular to NS, he obferved it to become fenfibly more feeble, vibrating more flowly; and when in a certain point E, it had no polarity whatever towards A and B, but retained any pofition that was given it. Carrying it farther out, it again acquired polarity to A and B, but in the oppofite direction; for it now arranged itfelf in a pofition that was parallel to NS, but its north pole was next to N, and its fouth pole to S.

This fingular appearance naturally excited his attention. The line on which the magnets A and B were placed had been marked on the table, as alfo the line DF perpendicular to the former. The point E was now marked as an important one. The experiments were interrupted by a friend coming in, to whom fuch things were no entertainment. Next day, wifhing to repeat them to fome friends, the magnets A and B were again laid on the line on which they had been placed the day before, and the needle was placed at E, expecting it to be neutral. But it was found to have a confiderable verticity, turning its north pole toward the magnet B; and it required to be taken farther out, toward F, before it became neutral. While ftanding there, fomething chanced to joggle the magnets A and B, and they inftantly rufhed together. At the fame inftant, the little magnet or needle turned itfelf brifkly, and arranged itfelf, as it had done the day before, at F, quivering very brifkly, and thus fhewing great verticity. This naturally furprifed the beholders; and we now found that, by gradually withdrawing the magnets A and B from each other, the needle became weaker—then became neutral—and then turned round on its pivot, and took the contrary pofition. It was very amufing to obferve how the fimply feparating the magnets A and B, or bringing them together, made the needle affume fuch a variety of pofitions and degrees of vivacity in each.

The needle was now put in various fituations, in refpect to the two great magnets; namely, off at a fide, and not in the perpendicular DF. In thefe fituations, it took an inconceivable variety of pofitions, which could not be reduced to any rule; and in moft of them it required only a motion of one of the great magnets for an inch or two, to make the needle turn brifkly round on its pivot, and affume a pofition nearly oppofite to what it had before.

But all this was very puzzling, and it was not till after feveral months that the writer of this article, having conceived the notion of the magnetic curves, was in a condition to explain the phenomena. With this affiftance, however, they are very clear, and very inftructive.

Nothing hinders us from fuppofing the magnets A and B perfectly equal in every refpect. Let NHM, NEL, be two magnetic curves belonging to A; that is, fuch that the needle arranges itfelf along the tangent of the curve. Then the magnet B has two curves SGK, SEI, perfectly equal, and fimilar to the other two. Let the curves NHM and SGK interfect in C and F. Let the curves NEL and SEI touch each other in E.

The needle being placed at C, would arrange itfelf in the tangent of the curve KGS, by the action of B alone, having its north pole turned toward the fouth pole S of B. But, by the action of A alone, it would be a tangent to the curve NHM, having its north pole turned away from N. Therefore, by the combined action of both magnets, it will take neither of thefe pofitions, but an intermediate one, nearly bifecting the angle formed by the two curves, having its north pole turned toward B.

But remove the needle to F. Then, by the action of the magnet A, it would be a tangent to the curve FM, having its north pole toward M. By the action of B, it would be a tangent to the curve KFG, having its north pole in the angle MFG, or turned toward A. By their joint action, it takes a pofition nearly bifecting the angle GFM, with its north pole toward A.

Let the needle be placed in E. Then, by the action of the magnet A, it would be a tangent to the curve NEL, with its north pole pointing to F. But, by the action of B, it will be a tangent to SEI, with its north pole pointing to D. Thefe actions being fuppofed equal and oppofite, it will have no verticity, or will be neutral, and retain any pofition that is given to it.

The curve SEI interfects the curve NHM in P and Q. The fame reafoning fhews, that when the needle is placed at P, it will arrange itfelf with its north pole on the angle SPH: but, when taken to Q, it will ftand with its north pole in the angle EQM.

From thefe facts and reafonings we muft infer, that, for every diftance of the magnets A and B, there will be a feries of curves, to which the indefinitely fhort needle will always be a tangent. They will rife from the adjoining poles on both fides, croffing diagonally the lozenges formed by the PRIMARY or SIMPLE curves, as in fig. 6. Thefe may be called COMPOUND or SECONDARY magnetic curves. Moreover, thefe fecondary curves will be of two kinds, according as they paſs through the firſt or ſecond interſections of the primary curves, and the needle will have oppoſite poſitions when placed on them. Theſe two ſets of curves will be ſeparated by a curve GEH, in the circumference of which the needle will be neutral. This curve paſſes through the points where the primary curves touch each other. We may call this the *line of neutrality* or inactivity.

We now ſee diſtinctly the effect of bringing the magnets A and B nearer together, or ſeparating them farther from each other. By bringing them nearer to each other, the point E, which is now a point of neutrality, may be found in the *ſecond* interſection (ſuch as F) of two magnetic curves, and the needle will take a ſubcontrary poſition. By drawing them farther from each other, E may be in the *firſt* interſection of two magnetic curves, and the needle will take a poſition ſimilar to that of C.

If the magnets A and B are not placed ſo as to form a ſtraight line with their four poles, but have their axes making an angle with each other, the contacts and interſections of their attending curves may be very different from thoſe now repreſented; and the poſitions of the needle will differ accordingly. But it is plain, from what has been ſaid, that if we knew the law of action, and conſequently the form of the primary curves, we ſhould always be able to ſay what will be the poſition of the needle. Indeed, the conſideration of the ſimple curves, although it was the mean of ſuggeſting to the writer of this article the explanation of thoſe more complicated phenomena, is by no means neceſſary for this purpoſe. Having the law of magnetic action, we muſt know each of the eight forces by which the needle is affected, both in reſpect of direction and intenſity; and are therefore able to aſcertain the ſingle force ariſing from their compoſition.

Secondary curves of repulſion. When the ſimilar poles of A and B are oppoſed to each other, it is eaſy to ſee, that the poſition of the needle muſt be extremely different from what we have been deſcribing. When placed anywhere in the line DF, between two magnets, whoſe north poles front each other in N and S, its north pole will always point away from the middle point D. There will be no neutral point E. If the needle be placed at P or Q, its north pole will be within the angle EPH, or FQI. This poſition of the magnets gives another ſet of ſecondary curves, which alſo croſs the primary curves, paſſing diagonally through the lozenges formed by their interſection. But it is the other diagonal of each lozenge which is a chord to thoſe ſecondary curves. They will, therefore, have a form totally different from the former ſpecies.

30 Remarks on this inveſtigation. The conſideration of this compound magnetiſm is important in the ſcience, both for explaining complex phenomena, and for advancing our knowledge of the great deſideratum, the law of magnetic action. It ſerves this purpoſe remarkably. By employing a very ſmall needle, the points of neutrality aſcertain very nearly where the magnetic curves have a common tangent, and ſhews the poſition of this tangent. By placing the two magnets ſo as to form various angles with each other, we can, by means of theſe neutral points, know the poſition of the tangent in every point of the curve, and thus can aſcertain the form of the curve, and the law of action, with conſiderable accuracy. The writer of this article took this method; and the reſult confirmed him in the opinion, that it was in the inverſe duplicate ratio of the diſtances. The chief (perhaps the only) ground of error ſeemed to be the difficulty of procuring large magnets, having the action of each pole very much concentrated. Large magnets muſt be employed. He attempted to make ſuch, conſiſting of two ſpherical balls, joined by a ſlender rod. But he could not give a ſtrong magnetiſm to magnets of this form, and was forced to make uſe of common bars, the poles of which are conſiderably diffuſed. This diffuſion of the pole renders it very difficult to ſelect with propriety the points from which the diſtances are to be eſtimated, in the inveſtigation of the relation between the forces and diſtances.

He tried another method for aſcertaining this ſo much deſired law, which had alſo the ſame reſult. Having made a needle conſiſting of two balls joined by a ſlender rod, and having touched it with great care, ſo that the whole ſtrength of its poles ſeemed very little removed from the centres of the balls, he counted the number of horizontal vibrations which it made in a given time by the force of terreſtrial magnetiſm. He then placed it on the middle of a very fine and large magnet, placed with its poles in the magnetic meridian, the north pole pointing ſouth. In this ſituation he counted the vibrations made in a given time. He then raiſed it up above the centre of the large magnet, till the diſtance of its poles from thoſe of the great magnet were changed in a certain proportion. In this ſituation its vibrations were again counted. It was tried in the ſame way in a third ſituation, conſiderably more remote from the great magnet. Then, having made the proper reduction of the forces correſponding to the obliquity of their action, the force of the poles of the great magnet was computed from the number of vibrations. To ſtate here the circumſtances of the experiment, the neceſſary reductions, and the whole computations, would occupy ſeveral pages, and to an intelligent reader would anſwer little purpoſe. Mr Lambert's excellent diſſertation in the 22d vol. of the *Mem. de l'Acad. de Berlin*, will ſhew the prolixity and intricacy of this inveſtigation. Suffice it to ſay, that theſe experiments were the moſt conſiſtent with each other of any made by the writer of this article, with the view of aſcertaining the law of magnetic action; and it is chiefly from their reſult that he thinks himſelf authoriſed to ſay, with ſome confidence, that it is inverſely as the ſquare of the diſtance. Theſe experiments were firſt made in a rough way in 1769 and 1770. In 1775, obſerving that Mr Æpinus ſeemed to think the action inverſely as the diſtance (ſee his *Tentam. Theor. Electr. et Magn.* § 301. &c.), they were repeated with very great care; and to theſe were added another ſet of experiments, made with the ſame magnet and the ſame needle, placed not above the magnet, but at one ſide (but always in the line through the centre, perpendicular to the axis, ſo that the actions of the two poles might be equal). This diſpoſition evidently ſimplifies the proceſs exceedingly. The reſult of the whole was ſtill more ſatisfactory. This concluſion is alſo confirmed by the experiments of Mr Coulomb in the Memoirs of the Academy of Sciences at Paris for 1786 and 1787. It would ſeem therefore to be pretty well eſtabliſhed. Another method, which ſeems ſuſceptible of

conſiderable

conſiderable accuracy, ſtill remains to be tried. It will be mentioned in due time.

Such then are the general laws obſerved in the mutual action of magnets. We think it ſcarcely neceſſary to enter into a farther detail of their conſequences, correſponding to the innumerable varieties of poſitions in which they may be placed with reſpect to each other. We are confident, that the ſenſible actions will always be found agreeable to the legitimate conſequences of the general propoſitions which we have eſtabliſhed in the preceding paragraphs. We proceed therefore to conſider ſome phyſical facts not yet taken notice of which have great influence on the phenomena, and greatly aſſiſt us in our endeavours to underſtand ſomething of their remote cauſe.

31 agnetiſm tempora- and pe- hing.

Magnetiſm, in all its modifications of attraction, repulſion, and direction, is, in general, of a temporary or periſhing nature. The beſt loadſtones and magnets, unleſs kept with care, and with attention to certain circumſtances, are obſerved to diminiſh in their power. Natural loadſtones, and magnets made of ſteel, tempered as hard as poſſible, retain their virtue with greateſt obſtinacy, and ſeldom loſe it altogether, unleſs in ſituations which our knowledge of magnetiſm teaches us to be unfavourable to its durability. Magnets of tempered ſteel, ſuch as is uſed for watch-ſprings, are much ſooner weakened, part with a greater proportion of their force by ſimple keeping, and finally retain little or none. Soft ſteel and iron loſe their magnetiſm almoſt as ſoon as its producing cauſe is removed, and cannot be made to retain any ſenſible portion of it, unleſs their metallic ſtate ſuffer ſome change.

Hurt by roper tion.

1. Nothing tends ſo much to impair the power of a magnet as the keeping it in an improper poſition. If its axis be placed in the magnetic direction, but in a contrary poſition, that is, with the north pole of it where the ſouth pole tends to ſettle, it will grow weaker from day to day; and unleſs it be a natural loadſtone, or be of hard tempered ſteel, it will, after no very long time, loſe its power altogether.

By heat; ects of nder electri-

2. This diſſipation of a ſtrong magnetic power is greatly promoted by heat. Even the heat of boiling water affects it ſenſibly; and if it be made red hot, it is entirely deſtroyed. This laſt fact has long been known. Dr Gilbert tried it with many degrees of violent heat, and found the conſequences as now ſtated; but having no thermometers in that dawn of ſcience, he could not ſay any thing preciſe. He only obſerves, that it is deſtroyed by a heat not ſufficient to make it viſible in a dark room. Mr Canton found even boiling water to weaken it; but on cooling again the greateſt part was recovered.

By vio- treat- nt.

3. What is more remarkable, magnetiſm is impaired by any rough uſage. Dr Gilbert found, that a magnet which he had impregnated very ſtrongly, was very much impaired by a ſingle fall on the floor; and it has been obſerved ſince his time, that falling on ſtones, or receiving any concuſſion which cauſes the magnet to ring or ſound, hurts it much more than beating it with any thing ſoft and yielding. Grinding a natural loadſtone with coarſe powders, to bring it into ſhape, weakens it much; and loadſtones ſhould therefore be reduced into a ſhape as little different from their natural form as poſſible; and this ſhould be done briſkly, cutting them with the thin diſks of the lapidary's wheel, cutting off only what is neceſſary for leaving their moſt active parts or poles as near their extremities as we can.

All theſe cauſes of the diminution of magnetiſm are more operative if the magnet be all the while in an improper poſition.

4. Laſtly, magnetiſm is impaired and deſtroyed by placing the magnet near another magnet, with their ſimilar poles fronting each other. We have had occaſion to remark this already, when mentioning the experiments made with magnets in this poſition, for aſcertaining the general laws or variations of their repulſion. We there obſerved, that magnets ſo ſituated always weakened each other, and that a powerful magnet often changed the ſpecies of the neareſt pole of one leſs powerful. This change is recovered, in part at leaſt, when it has taken place in a loadſtone or a magnet of hard ſteel; but in ſpring tempered ſteel the change is generally permanent, and almoſt to the full extent of its condition while the magnets are together. It is to be remarked, that this change is gradual; and is expedited by any of the other cauſes, particularly by heat or by knocking. 4. By other magnets.

32 Magnetiſm may be acquired.

On the other hand, magnetiſm is acquired by the ſame means, when ſome other circumſtances are attended to.

1. A bar of iron, which has long ſtood in the magnetic direction, or nearly ſo, will gradually acquire magnetiſm, and the ends will acquire the polarity correſponding to their ſituation. In this country, and the north of Europe, the old ſpindles of turret vanes, old bars of windows, &c. acquire a ſenſible magnetiſm; their lower extremity becoming a north pole, and the other end a ſouth pole. Gilbert ſays, that this was firſt obſerved in Mantua, in the vane ſpindle of the Auguſtine church—"*Vento flexa* (ſays he) *de prompta et apothecario cuidam conceſſa, attrahebat ferrea ramenta, vi perquam inſigni.*" The upper bar of a hand rail to a ſtair on the north ſide of the higheſt part of the ſteeple of St Giles's church in Edinburgh is very magnetical; and the upper end of it, where it is lodged in the ſtone, is a vigorous ſouth pole. It is worth notice, that the parts of ſuch old bars acquire the ſtrongeſt magnetiſm when their metallic ſtate is changed by expoſure to the air, becoming foliated and friable. It would be worth while to try, whether the æthiops martialis, produced by ſteam in the experiments for decompoſing water, will acquire magnetiſm during its production. The pipe and the wires, which are converted into the ſhining æthiops ſhould be placed in the magnetic direction. 1 By magnetical poſition;

2. If a bar of ſteel be long hammered while lying in the magnetic direction, it acquires a ſenſible magnetiſm (See Dr Gilbert's plate, repreſenting a blackſmith hammering a bar of iron in the magnetic direction). The points of drills, eſpecially the great ones, which are urged by very great preſſure; and broaches, worked by a long lever, ſo as to cut the iron very faſt, acquire a ſtrong magnetiſm, and the lower end always becomes the north pole (*Phil. Tranſ.* xx. 417.) Even driving a hard ſteel punch into a piece of iron, gives it magnetiſm by a ſingle blow. In ſhort, any very violent ſqueeze given to a piece of tempered ſteel renders it magnetic, and its polarity correſponds with its poſition during the experiment. We can ſcarcely take up a cutting or boring tool in a ſmith's ſhop that is not magnetical. Even 2. By hammering;

ſoft ſteel and iron acquire permanent magnetiſm in this way. Iron alſo acquires it by twiſting and breaking. It is therefore difficult to procure pieces of iron or ſteel totally void of determinate and permanent magnetiſm; and this frequently mars the experiments mentioned in the firſt paragraphs of this article. The way therefore to enſure ſucceſs in theſe experiments is to deprive the rods of their accidental magnetiſm, by ſome of the methods mentioned a little ago. Let them be heated red hot, and allowed to cool while lying in a direction perpendicular to the magnetic direction (nearly E. N. E. and W. S. W. in this country).

3. By heating; 3. As heat is obſerved to deſtroy magnetiſm, ſo it may alſo be employed to induce it on ſubſtances that are ſuſceptible of magnetiſm. Dr Gilbert makes this obſervation in many parts of his work. He ſays, that the ores of iron which are in that particular metallic ſtate which he conſiders as moſt ſuſceptible of magnetiſm, will acquire it by long continuance in a red heat, if laid in the magnetic direction, and that their polarity is conformable to their poſition, that end of the maſs which is next the north becoming the north pole. He alſo made many experiments on iron and ſteel bars expoſed to ſtrong heats in the magnetical direction. Such experiments have been made ſince Gilbert's time in great number. Dr Hooke, in 1684, made experiments on rods of iron and ſteel one-fifth of an inch in diameter, and ſeven inches long. He found them to acquire permanent magnetiſm by expoſure to ſtrong heat in the magnetic direction, and if allowed to cool in that direction. But the magnetiſm thus acquired by ſteel rods was much ſtronger, and more permanent, if they were ſuddenly quenched with cold water, ſo as to temper them very hard. He found, that the end which was next to the north, or the lower end of a vertical bar, was always its permanent north pole. Even quenching the upper end, while the reſt was ſuffered to cool gradually, became a very ſenſible ſouth pole. No magnetiſm was acquired if this operation was performed on a rod lying at right angles to the magnetical direction.

In theſe trials the polarity was always eſtimated by the action on a mariner's needle, and the intenſity of the magnetiſm was eſtimated by the deviation cauſed in this needle from its natural poſition. Dr Gilbert made a very remarkable obſervation, which has ſince been repeated by Mr Cavallo, and publiſhed in the Philoſophical Tranſactions as a remarkable diſcovery. Dr Gilbert ſays, p. 69. "*Bacillum ferreum, valide ignitum appone verſorio excito; ſtat verſorium, nec ad tale ferrum convertitur: ſed ſtatim ut primum de candore aliquantulum remiſerit, confluit illico.*" In ſeveral other parts of his treatiſe he repeats the ſame thing with different circumſtances. It appears, therefore, that while iron is red hot, it is not ſuſceptible of magnetiſm, and that it is during the cooling in the magnetic direction that it acquires it. Gilbert endeavoured to mark the degree of heat moſt favourable for this purpoſe; but being unprovided with thermometers, he could not determine any thing with preciſion. He ſays, that the verſorium, or mariner's needle, was moſt deranged from its natural poſition a little while after the bar of iron ceaſed to ſhine in day light, but was ſtill pretty bright in a dark room. But there are other experiments which we have made, and which will be mentioned by and bye; by which it appears, that although a bright red or a white heat makes iron unſuſceptible of magnetiſm while in that ſtate, it prediſpoſes it for becoming magnetical. When a bar of ſteel was made to acquire magnetiſm by tempering it in the magnetical direction, we found that the acquired magnetiſm was much ſtronger when the bar was made firſt of all very hot, even although allowed to come to its moſt magnetical ſtate before quenching, than if it had been heated only to that degree; nay, we always found it ſtronger when it was quenched when red hot. We offer no explanation at preſent; our ſole buſineſs juſt now being to ſtate facts, and to generalize them, in the hopes of finding ſome fact which ſhall contain all the others.

4. The moſt diſtinct acquiſitions and changes of magnetiſm are by juxtapoſition to other magnets and to iron. 4. By juxtapoſition. As the magnetiſm of a loadſtone or magnet is weakened by bringing its pole near the ſimilar pole of another magnet, it is improved by bringing it near the other pole; and it is always improved by bringing it near any piece of iron or ſoft ſteel.

But this action, and the mutual relation of magnets and common iron, being the moſt general, and the moſt curious and inſtructive of all the phenomena of magnetiſm, they merit a very particular conſideration.

Of the communication of Magnetiſm.

33 Communication of magnetiſm.

THE whole may be comprehended in one propoſition, which may be ſaid to contain a complete theory of magnetiſm.

Fundamental propoſition.

Any piece of iron, when in the neighbourhood of a magnet, is a magnet, and its polarity is ſo diſpoſed that the magnet and it mutually attract each other.

The phenomena which reſult from this fundamental principle are infinitely various, and we muſt content ourſelves with deſcribing a ſimple caſe or two, which will ſufficiently enable the reader to explain every other.

34. Attractive power communicated.

Take a large and ſtrong magnet NAS (fig. 7.), of which N is the north, and S the ſouth pole. Let it be properly ſupported in a horizontal poſition, with its poles free, and at a diſtance from iron or other bodies. Take any ſmall piece of common iron, not exceeding two or three inches in length, ſuch as a ſmall key. Take alſo another piece of iron, ſuch as another ſmaller key, or a bit of wire about the thickneſs of an ordinary quill.

1. Hold the key horizontally, near one of the poles, (as ſhewn at n° 1.), taking care not to touch the pole with it; and then bring the other piece of iron to the other end of the key (it is indifferent which pole is thus approached with the key, and which end of the key is held near the pole). The wire will hang by the key, and will continue to hang by it, when we gradually withdraw the key horizontally from the magnet, till, at a certain diſtance, the wire will drop from the key, becauſe the magnetiſm imparted from this diſtance is too weak. That this is the ſole reaſon of its dropping, will appear by taking a ſhorter, or rather a ſlenderer, bit of wire, and touch the remote end of the key with it: it will be ſupported, even though we remove the key ſtill farther from the magnet.

2. Hold the key *below* one of the poles, as at n° 2. or 3. and touch its remote end with the wire. It will be ſuſpended in like manner, till we remove the key too far from the magnet.

3. Hold

3. Hold the key *above* the poles, as at n° 4. or 5. and touch its adjacent end with the wire (taking care that the wire do not alſo touch the magnet). The wire will ſtill be ſupported by the key, till both are removed too far from the magnet.

Thus it appears that, in all theſe ſituations, the key has ſhewn the characteriſtic phenomenon of magnetiſm, namely, attraction for iron. In the experiment with the key held above the pole, the wire is in the ſame ſituation in reſpect to magnetiſm as the key is when held below the pole; but the actions are mutual. As the key attracts the wire, ſo the wire attracts the key.

If the magnet be ſupported in a vertical poſition, as in fig. 8. the phenomena will be the ſame; and when the key is held directly above or directly below the pole, it will carry rather a heavier wire than in the horizontal poſition of the magnet and key.

Inſtead of approaching the magnet with the key and wire, we may bring the magnet toward them, and the phenomena will be ſtill more palpable. Thus, if the bit of wire be lying on the table, and we touch one end of it with the key, they will ſhew no connection whatever. While we hold the key very near one end of the wire, bring down the pole of a magnet toward the key, and we ſhall then ſee the end of the wire riſe up and ſtick to the key, which will now ſupport it. In like manner, if we lay a quantity of iron filings on the table, and touch them with the key, in the abſence of the magnet, we find the key totally inactive. But, on bringing the magnet anyhow near the key, it immediately attracts the iron filings, and gathers up a heap of them.

35 Alſo a directive power.

In the next place, this vicinity of a magnet to a piece of iron gives it a directive power. Let NAS (fig. 9.) be a magnet, and BC (n° 1.) a key held near the north pole, and in the direction of the axis. Bring a very ſmall mariner's needle, ſupported on a ſharp point, near the end C of the key which is fartheſt from N. We ſhall ſee this needle immediately turn its ſouth pole towards C, and its north pole away from C. This poſition of the needle is indicated at *c*, by marking its north pole with a dart, and its ſouth with a croſs. Thus it appears that the key has got a directive power like a magnet, and that the end C is performing the office of a north pole, attracting the ſouth pole of the needle, and repelling its north pole. It may indeed be ſaid, that the needle at *c* arranges itſelf in this manner by the directive power of the magnet; for it would take the ſame poſition although the key were away. But if we place the needle at *b*, it will arrange itſelf as there repreſented, ſhewing that it is influenced by the key, and not (wholly at leaſt) by the magnet. In like manner, if we place the needle at *a*, we ſhall ſee it turn its north pole toward B, notwithſtanding the action of the magnet on it. This action evidently tends to turn its north pole quite another way: but it is influenced by B, and B is performing the office of a ſouth pole.

In like manner, if we place the key as at n° 2. we ſhall obſerve the end B attract the ſouth pole of the needle placed at *a*, and the end C attract the north pole of a needle placed in *b*. In this ſituation of the key, we ſee that B performs the office of a north pole, and C performs the office of a ſouth pole.

Thus it appears that the key in both ſituations has become a magnet, poſſeſſed of both an attractive and a directive power. It has acquired two poles.

36 The attraction of iron is owing to the diſpoſition of its own temporary magnetiſm.

Laſtly, the magnetiſm of the key is ſo diſpoſed that the two magnets NAS and BC muſt mutually attract each other; for their diſſimilar poles front each other. Now, it is a matter of uniform and uncontradicted obſervation, that when a piece of iron is thus placed near a magnet, and the diſpoſition of its magnetiſm is thus examined by means of a mariner's needle, the diſpoſition is ſuch that two permanent magnets with their poles ſo diſpoſed muſt attract each other. The piece of iron, therefore, having the ſame magnetic relation to the magnet that a ſimilar and ſimilarly diſpoſed magnet has, muſt be affected in the ſame manner. We cannot, by any knowledge yet contained in this article, give any preciſe intimation in what way the polarity of the piece of iron will be diſpoſed. This depends on its ſhape as much as on its poſition. By deſcribing two or three examples, a notion is obviouſly enough ſuggeſted, which, although extremely gratuitous, and perhaps erroneous, is of ſervice, becauſe it has a general analogy with the obſerved appearances.

If one end of a ſlender rod or wire be held near the north pole of the magnet, while the rod is held in the direction of the axis (like the key in fig. 7. n° 1.), the near end becomes a ſouth, and the remote end a north pole. Keeping this ſouth pole in its place, and turning the rod in any direction from thence, as from a centre, the remote end is always a north pole. And, in general, the end of any oblong piece of iron which is neareſt to the pole of a magnet becomes a pole of the oppoſite name, while the remote end becomes a pole of the ſame name with that of the magnet.

If the iron rod be held perpendicularly to the axis, with its middle very near the north pole of the magnet, the two extremities of the iron become north poles, and the middle is a ſouth pole.

If the north pole of a magnet be held perpendicular to the centre of a round iron plate, and very near it, this plate will have a ſouth pole in its centre, and every part of its circumference will have the virtue of a north pole.

If the plate be ſhaped with points like a ſtar, each of theſe points will be a very diſtinct and vigorous north pole.

Something like this will be obſerved in a piece of iron of any irregular ſhape. The part immediately adjoining to the north pole of the magnet will have the virtue of a ſouth pole, and all the remote protuberances will be north poles.

The notion naturally ſuggeſted by theſe appearances is, that the virtue of a north pole ſeems to reſide in ſomething that is moveable, and that is protruded by the north pole of the magnet toward the remote parts of the iron; and is thus conſtipated in all the remote edges, points, and protuberances, much in the ſame manner as electricity is obſerved to be protruded to the remote parts and protuberances of a conducting body by the preſence of an overcharged body. This notion will greatly aſſiſt the imagination; and its conſequences very much reſemble what we obſerve.

As a farther mark of the complete communication of every magnetic power by mere vicinity to a magnet, we may here obſerve that the wire D, of fig. 7. n° 2. and 3. will ſupport another wire, and this another; and ſo,

on,

on, to a number depending on the ſtrength of the magnet. The key has therefore become a true magnet in every reſpect; for it induces complete magnetiſm on the appended wire. That this is not the ſame operation of the great magnet (at leaſt not wholly ſo), appears by examining the magnetiſm of D with the needle, which will be ſeen to be more influenced by D than by A. This fact has been long known. The ancients ſpeak of it: They obſerve, that a loadſtone cauſes an iron ring to carry another ring, and that a third; and ſo on, till the ſtring of rings appears like a chain.

37 Exception explained. What has now been ſaid will explain a ſeeming exception to the univerſality of the propoſition. If the key be held in the ſituation and poſition repreſented by fig. 10. the bit of wire will not be attracted by it; and we may imagine that it has acquired no magnetiſm: But if we bring a mariner's needle, or a bit of wire, near to its remote end B, it will be ſtrongly attracted, and ſhew B to be a north pole. The needle held near to C will alſo ſhew C to be a ſouth pole. Alſo, if held near to D, it will ſhew D to be a north pole. Now the ends C, both of the key and of the wire, being ſouth poles, they cannot attract each other, but, on the contrary, they will repel; and therefore the wire will not adhere to the key. And if the key of fig. 17. n° 4. with the wire hanging to it, be gradually carried outward, beyond the north pole of the magnet, and then brought down till its lower end be level with the pole, the wire will drop off.

There is however, one exception to the propoſition. If the key in fig. 7. with its appending wire D, be gradually carried from any of the ſituations 2, 3, 4, or 5, toward the middle of the magnet, the wire will drop off whenever it arrives very near the middle. If we ſuppoſe a plane to paſs through the magnetic centre A', perpendicular to the axis (which plane is very properly called the magnetic equatorial plane by Gilbert), a ſlender piece of iron, held anywhere in this plane, acquires no ſenſible magnetiſm. It gives no indication of any polarity, *and it is not attracted by the magnet.* It is well known, that the activity of a loadſtone or magnet reſides chiefly in two parts of it, which have been called its poles; and that thoſe are the beſt magnets or loadſtones in which this activity is leaſt diffuſed; and that a certain circumference of every loadſtone or magnet is wholly inactive. When a loadſtone or magnet of any ſhape is laid among iron filings, it collects them on two parts only of its ſurface, and between theſe there is a ſpace all round, to which no filings attach themſelves.

We preſume that the reader already explains this appearance to himſelf. Many things ſhew a contrariety of action of the two poles of a magnet. We have already obſerved, that the north pole of a ſtrong magnet will produce a ſtrong northern polarity in the remote end of a ſmall ſteel bar; and if it be then applied near to that end in the oppoſite direction, it will deſtroy this polarity, and produce a ſouthern polarity. In whatever theſe actions may conſiſt, there is ſomething not only different but oppoſite. They do not blend their effects, as the yellow and blue making rays do in producing green. They oppoſe each other, like mechanical preſſures or impulſions. We have every mark of mechanical action; we have local motion, though unſeen, except in the gradual progreſſion of the magnetical faculties along the bar; but we have it diſtinctly in the ultimate effect, the approach or receſs of the magnets: and in theſe phenomena we ſee plainly, that the forces, in producing their effects, act in oppoſite directions. Whatever the internal inviſible motions may be, they are compoſed of motions whoſe equivalents are the ſame with the equivalents of the ultimate, external, ſenſible motions; therefore the internal motions are oppoſite and equal if the ſenſible motions are ſo, and converſely.

Adopting this principle, therefore, that the actions of the two poles are not only different but oppoſite, it follows, that if they are alſo equal and act ſimilarly, each muſt *prevent* the action of the other; and that there will be a mechanical equilibrium—it may even be called a magnetical equilibrium. Therefore if every part of a ſlender rod, or of a thin plate of iron, lie in the plane of the magnetic equator, the magnetic ſtate (in whatever it may conſiſt) cannot be produced in it. It will exhibit no magnetiſm; have no polar faculties; and we can ſee no reaſon why it ſhould be attracted by the magnet, or ſhould attract iron. We muſt not forget to obſerve in this place, that iron in a ſtate of incandeſcence acquires no magnetiſm by juxtapoſition. We have already remarked, that iron in this ſtate does not affect the magnet. If a bar of red hot iron be ſet near a mariner's needle, it does not affect it in the ſmalleſt degree till it almoſt ceaſes to appear red hot in day-light, as has been obſerved by Dr Gilbert. All actions that we know are accompanied by equal and oppoſite re-actions; and we ſhould expect, what really happens in the preſent caſe, namely, that red hot iron ſhould not be rendered magnetical and attractable.

38 Magnetiſm not impaired by communication. There is a very remarkable circumſtance which accompanies the whole of this communication of magnetiſm to a piece of iron. It does not impair the power of the magnet; but, on the contrary, improves it. This fact was obſerved, and particularly attended to, by Dr Gilbert. He remarks, that a magnet, in the hands of a judicious philoſopher, may be made to impart more magnetiſm than it poſſeſſes to each of ten thouſand bars of ſteel, and that it will be more vigorous than when the operations began. A magnet (ſays he) may be ſpoiled by injudicious treatment with other magnets, but never can touch a piece of common iron without being improved by it. He gives a more direct proof. Let a magnet carry as heavy a lump of iron as poſſible by its lower pole. Bring a great lump of iron cloſe to its upper pole, and it will now carry more. Let it be loaded with as much as it can carry while the lump of iron touches its upper pole. Remove this lump, and the load will inſtantly drop off. But the following experiment ſhews this truth in the moſt convincing manner:

Let NAS (fig. 11.) be a magnet, not very large, nor of extreme hardneſs. Let CD be a ſtrong iron wire, hanging perpendicularly from a hook by a ſhort thread or loop. The magnet, by its action on CD, renders D a north pole and C a ſouth pole, and the polarity of D's magnetiſm fits it for being attracted. Let it aſſume the poſition C *e*, and let this be very carefully marked. Now bring a great bar of iron *s* B *n* near to the other end of the magnet. We ſhall inſtantly perceive the wire C *e* approach to the ſouth pole of the magnet, taking a poſition C *f*. Withdraw the bar of iron, and C *f* will fall back into the poſition C *e*. As we bring the iron bar gradually nearer to the magnet, the

the wire will deviate farther from the perpendicular, and when the bar B touches the magnet CD, will ſtart a great way forward. It is alſo farther to be obſerved, that the larger the bar of iron is, the more will CD deviate from the perpendicular.

Now this muſt be aſcribed to the action of the bar on the magnet. For if the magnet be removed, the bar alone will make no ſenſible change on the poſition of the wire. We know that the bar of iron becomes magnetical by the vicinity of the magnet. If we doubt this, we need only examine it by means of a piece of iron or a mariner's needle. This will ſhew us that *s* has become a ſouth, and *n* a north pole. Here then are two magnets with their diſſimilar poles fronting each other. In conformity with the whole train of magnetical phenomena, we muſt conclude that they attract each other, and muſt improve each other's magnetiſm.

39 erefore thing is nsferred. This is a moſt important circumſtance in the theory of magnetiſm. For it ſhews us, that, in rendering a piece of iron magnetic, there is no material communication. There is no indication of the transference of any ſubſtance reſiding in the magnet into the piece of iron; nor is there even any transference of a power or quality. Were this the caſe, or if the ſubſtance or quality which was in A be now transferred to B, it can no longer be in A; and therefore the phenomena reſulting from its preſence and agency muſt be diminiſhed. We muſt ſay that the magnet has excited powers inherent, but dormant, in the iron; or is, at leaſt, the occaſion of this excitement, by diſturbing, in ſome adequate manner, the primitive condition of the iron. We muſt alſo ſay, that the competency of the magnet and of the iron to produce the phenomena, is owing to the ſame circumſtances in both; becauſe we ſee nothing in the phenomena which authoriſes us to make any diſtinction between them. Whatever therefore cauſes one magnet to attract another, is alſo the reaſon why a piece of iron in the neighbourhood of a magnet attracts another piece of iron; and we muſt ſay that the cauſe of polarity, or the origin of the directive power, is the ſame in both. Now we underſtand perfectly the directive power of a magnet, as exerted on another magnet. We ſee that it ariſes from a combination and mechanical compoſition of attractions and repulſions. It muſt be the ſame in this magnetiſm now inherent in the iron. The piece of iron directs the mariner's needle, as a magnet would direct it; therefore, as there is ſomething in a piece of iron which *now* attracts ſomething in another piece of iron, ſo there is ſomething in the firſt which repels ſomething in the laſt.

40 jections ſwered a curious t. It may indeed be ſaid that it is not a piece of iron, but a mariner's needle, or magnet, that is thus directed by our iron magnetiſed by vicinity to a magnet. This objection is completely removed by the moſt curious of all the facts which occur in this manner of producing magnetiſm. Take a piece of common iron, faſhion it, and fit it up preciſely like a mariner's needle, and carefully avoid every treatment that can make it magnetical. Set it on its pivot, and bring it near the north pole of a magnet, placing the end, made like the ſouth pole of the needle, next to the north pole of the magnet. In ſhort, place it by hand exactly as a real mariner's needle would arrange itſelf. It will retain that poſition. Now carry it round the magnet, along the circumference of a magnetic curve, or in any regular and continuous route. This piece of iron will, in every ſituation, aſſume the very ſame poſition or attitude which the real magnetical needle would aſſume if in the ſame place, and it will oſcillate preciſely in the ſame way.

Here then it is plain, that there is no diſtinction of power between the magnetiſm of the iron and of the real needle. To complete the proof: Inſtead of approaching the magnet with this iron needle, bring it into the vicinity of a piece of iron, which is itſelf magnetical only by vicinity to a magnet, it will arrange itſelf juſt as the real needle would do, with the ſole difference, that it does not indicate the *kind* of polarity exiſting in the extremities of the iron, becauſe either end of it will be attracted by them. And this circumſtance leads us to the conſideration of the only diſtinction between the magnetiſm of a loadſtone or magnet and that of common iron.

The magnetiſm of common iron is momentary, and therefore indifferent; whereas that of a magnet is permanent and determinate. When iron becomes magnetic in the way now mentioned, it remains ſo only while the magnet remains in its place; and when that is removed, the iron exhibits no ſigns of magnetiſm. Therefore when the north pole of a magnet has produced a ſouth pole in the neareſt end of an iron wire, and a north pole at its remote end, if we turn the magnet, and preſent its ſouth pole, the neareſt end of the wire inſtantly becomes a north pole, and the other a ſouth pole; and this change may be made as often, and as rapidly, as we pleaſe. This is the reaſon which made us direct the experimenter on the iron needle to begin his operation, by placing the end marked for a ſouth pole next to the north pole of the magnet. It becomes a real ſouth pole in an inſtant, and acts as ſuch during its peregrination round the magnet. But in any one of its ſituations, if we turn it half round with the finger, the end which formerly turned away from a pole of the magnet, will now turn as vigorouſly toward it. Therefore, in carrying the iron needle round the magnet, we directed the progreſs to be made in a continuous line, to avoid all chance of miſtaking the polarities. 41 Magnetiſm of iron is tranſitory and indifferent; but that of magnets is durable and determinate.

For all the reaſons now adduced, we think ourſelves obliged to ſay, that the magnetiſm produced on common iron by mere juxtapoſition to a magnet, is generated without any *communication* of ſubſtance or faculty. The power of producing magnetical phenomena is not *ſhared* between the magnet and the iron. We ſhall call it INDUCED MAGNETISM; MAGNETISM BY INDUCTION. 42 MAGNETISM OF INDUCTION.

We have ſaid that induced magnetiſm of common iron is quite momentary. This muſt be underſtood with careful limitations. It is ſtrictly true only in the caſe of the fineſt and pureſt ſoft iron, free of all knots and hard veins, and therefore in its moſt metallic ſtate. Iron is rarely found in a ſtate ſo very pure and metallic; and even this iron will acquire permanent and determinate magnetiſm by induction, if it had been twiſted or hammered violently, although not in the magnetic direction; alſo the changes produced (we imagine) on the pureſt iron by the action of the atmoſphere make it ſuſceptible of fixed magnetiſm. But the magnetiſm thus inducible on good iron is ſcarcely ſenſible, and of no duration, unleſs it has lain in the neighbourhood of a magnet for a very long while.

What has now been ſaid of common iron, is alſo true of it when in the ſtate of ſoft ſteel.

But

43 Tempered steel acquires durable magnetism.

But any degree of temper that is given to steel makes a very important change in this respect. In the first place, it acquires magnetism more slowly by induction than an equal and similar piece of common iron, and finally acquires less. These differences are easily examined by the deviations which it causes in the mariner's needle from the magnetic meridian, and by its attraction.

When the inducing magnet is removed, some magnetism remains in the steel bar, which retains the polarity which it had in the neighbourhood of the magnet.

Steel tempered to the degree fit for watch springs acquires a strong magnetism, which it exhibits immediately on the removal of the magnet. But it dissipates very fast; and, in a very few minutes, it is reduced to less than one-half of its intensity while in contact with the magnet, and not two-thirds of what it was immediately on removal from it. It continues to dissipate for some days, though the bar be kept with care; but the dissipation diminishes fast, and it retains at least one-third of its greatest power for any length of time, unless carelessly kept or injudiciously treated.

Steel tempered for strong cutting tools, such as chisels, punches, and drills for metal, acquires magnetism still more slowly by induction, and acquires less of it while in contact with the magnet: but it retains it more firmly, and finally retains a greater proportion of what it had acquired.

Steel made as hard as possible, is much longer in acquiring all the magnetism which simple juxtaposition can give to it. It acquires less than the former; but it retains it with great firmness, and finally retains a much greater proportion.

Such ores of iron as are susceptible of magnetism, are nearly like hard steel in these respects; that is, in the time necessary for their *greatest* impregnation, and in the durability of the acquired magnetism. They differ exceedingly in respect to the degree of power which they can attain by mere juxtaposition, and the varieties seem to depend on heterogeneous mixture. We must observe, that few ores of iron are susceptible of magnetism in their natural state. The ordinary ores, consisting of the metal in the state of an oxyd, and combined with sulphur, are not magnetizable while remaining in that state. Most ores require roasting, and a sort of cementation, in contact with inflammable substances. This matter is not well understood; but it would seem that complete metallization is far from being the most favourable condition, and that a certain degree of oxydation, and perhaps some other composition, yet unknown, make the best loadstones. But all this is extremely obscure. The late Dr Gowin Knight made a composition which acquired a very strong and permanent magnetism, but the secret died with him. Dr Gilbert speaks of similar compositions, in which ferrugineous clays were ingredients; but we know nothing of the state of the metal in them, nor their mode of acquiring magnetism.

44 Induction of magnetism is gradual and progressive.

It is of peculiar importance to remark that the acquisition of magnetism is gradual and progressive, and that the gradation is the more perceptible in proportion as the steel is of a harder temper. When a magnet is brought to one end of a bar of common iron, its remote extremity, unless exceedingly long, acquires its utmost magnetism immediately. But when the north pole of a magnet is applied to one end of a bar of hard steel, the part in contact immediately becomes a south pole, and the far end is not yet affected. We observe a north pole formed at some distance from the contact, and beyond this a faint south pole. These gradually advance along the bar. The remote extremity becomes first a faint south pole, and it is not till after a very long while (if ever) that it becomes a simple, vigorous, north pole. More frequently it remains a diffused and feeble north pole: nay, if the bar be very long, it often happens that we have a succession of north and south poles, which never make their way to the far end of the bar. This phenomenon was first observed (we think) by Dr Brook Taylor, who gives an account of his observations in the *Philosophical Transactions*, n° 344.

45 Iron is attracted only because it becomes magnetical.

From the account we have given of these phenomena of induced magnetism, it appears that the temporary magnetism is always so disposed that the sum of the mutual attractions of the dissimilar poles exceeds the sum of the repulsions between the similar poles, and that therefore the two magnets tend to each other. This is evidently equivalent to saying, that a piece of unmagnetic iron is always attracted by a magnet. No exception has ever been observed to this fact; for Pliny's story of a Theamedes, or loadstone, which repels iron, is allowed by all to have been a fable.

We think ourselves authorised to say that this attraction of the loadstone for iron, or this tendency of iron to the loadstone, is a secondary phenomenon, and is the *consequence* of the proper disposition of the induced magnetism. The proofs already given of the compound nature of this phenomenon, namely, that it arises from the excess of two attractions above two repulsions, need (we imagine) no addition. But the following considerations place the matter beyond doubt:

1. The magnetism of the two poles is evidently of an opposite nature; the one repelling what the other attracts. If the one attracts iron, therefore, the other should repel it. But each pole, by inducing a magnetism opposite to its own, on the nearest end of the iron, and the same with its own on the remote end, and its action diminishing with an increase of distance, there must always be an excess of attraction, and the iron must be attracted.

2. Each of the magnets A and B, in either of the positions represented in fig. 12. would alone attract the piece of common iron C. But when placed together, the south pole of A tends to render the upper end of C a north pole; while the north pole of B tends to make it a south pole. If their actions be nearly equal, the weight of C cannot be supported by the magnetism induced by any difference of action that may remain. While C is hanging by B alone, let A be gradually brought near; it gradually destroys the action of the north pole of B, so that C gradually loses its magnetism and polarity, and its weight prevails.

3. In all those cases where the induction of magnetism is slow, the attraction is weak in proportion. This is particularly remarked by Dr Gilbert. If we take pieces of common iron, and of steel of different tempers, but all of the same size and form, we shall find that the iron is much more strongly attracted than any of the rest, and that the attraction for each of them is weaker in proportion as they are harder. This diversity is so accurately observed, that when the piece is thoroughly suscep-

susceptible of magnetism, we can tell, with considerable precision, what degree will be ultimately acquired, and how much will be finally retained. Also, the attraction of the magnet for any of those pieces of steel increases exactly in proportion as their acquired magnetism increases.

4. An ore of iron incapable of acquiring magnetism is not attracted by a magnet. But we know that, by cementation with charcoal dust, they may be rendered susceptible of magnetism. In this state they are attracted. It is an universal fact, that any substance that is attracted by a magnet may be rendered magnetical, and that none else can. We have already observed that red hot iron is not attracted; nor does it acquire any directive power while in that state. From all this we must conclude, that the previous induction of magnetism is the mean of the observed attraction of magnets for iron, and that this is not a primary fact in magnetism.

These observations also complete the proof that magnetic attraction and repulsion are equal at the same distance, and follow the same law. Dr Gilbert seems to think that the repulsion is always weaker than the attraction; and this is almost the only mistake in conception into which that excellent philosopher has fallen. But it only requires a fair comparison of facts to convince a good logician, that since, *in every case*, and at every distance, either pole of a magnet attracts either end of a piece of common iron, it is impossible that one of these forces can exceed the other. It might be so, were it not that induced magnetism is durable in proper substances. And if we take magnets which have been made such by induction, and present them to each other with their similar poles fronting each other, they never fail to repel each other at considerable distances, and even at very small distances for a few moments; and this is the case whichever poles are next each other. This cannot be on any other supposition. Cases would occur of polarity without attraction, or of attraction without polarity. Such have never been seen, any more than the Theamedes, always repelling iron.

46 Phenomena of iron threads and filings.

Let a great number of small oblong pieces of iron be lying very near each other on the surface of quicksilver. Bring a strong magnet into the midst of them. It immediately renders them all magnetical by induction. The one nearest the north pole of the magnet immediately turns one end toward it, and the other end away from it. The same effect is produced on the one that is just beyond this nearest one. Thus the remote end of the first becomes a north pole, and the nearest end of the second becomes a south pole. These, being very near each other, must mutually attract. The same thing may be said of a third, a fourth, and so on. And thus it appears that not only is magnetism induced on them all, but also that the magnetism of each is so disposed, that both ends of it are in a state of attraction for the ends of some of its neighbours; and that they will therefore arrange themselves by coalescence in some particular manner. Should a parcel of them chance to be standing with their centres in a magnetic curve, with their heads and points turned in any ways whatever, the moment that the magnet is brought among them, and set in the axis of that magnetic curve, the whole pieces of this row will instantly turn towards each other, and their ends will adhere together, if they are near enough; otherwise they will only point toward each other, forming a set of tangents to the magnetic curve, reaching from one pole of the magnet to the other.

Or, suppose a vast number of small bits of iron, each shaped like a grain of barley, a little oblong. Let them be scattered over the surface of a table, so near each other as just to have room to turn round. Let a magnet be placed in the midst of them. They will all have magnetism induced on them in an instant; and such as are not already touching others, will turn round (because they rest on the table by one point only), and each will turn its ends to the ends of its neighbours; and thus they will arrange themselves in curves, which will not differ greatly from true magnetic curves (because each grain is very short), issuing from one pole of the magnet, and terminating in the other.

Does not this suggest to the reflecting reader an explanation of that curious arrangement of iron filings round a magnet, which has so long entertained and puzzled both the philosophers and the unlearned, and which has given rise to the Cartesian and other theories of magnetism? The particles of iron filings are little rags of soft iron torn off by the file, and generally a little oblong. These *must* have magnetism induced on them by a magnet, and, while falling through the air from the hand that strews them about the magnet, they are at perfect liberty to arrange themselves magnetically; and *must therefore so arrange themselves*, forming on the table curves, which differ very little indeed from the true magnetic curves. Suppose them scattered about the table before the magnet is laid on it. If we pat the table a little, so as to throw it into tremors, this will allow the particles to dance, and turn round on their points of support, till they coalesce by their ends in the manner already described.

All this is the genuine and inevitable consequence of what Dr Gilbert has taught us of induced magnetism. It must be so; and cannot be otherwise. This curious arrangement of iron filings round a magnet is therefore not a primary fact, and a foundation for a theory, but the result of principles much more general.

Most of our readers know that this disposition of iron filings has given rise to the chief mechanical theories which have been proposed by ingenious men for the explanation of all the phenomena of magnetism. An invisible fluid has been supposed to circulate through the pores of a magnet, running along its axis, issuing from one pole, streaming round the magnet, and entering again by the other pole. This is thought to be indicated by those lines formed by the filings. The stream, running also through *them*, or around them, arranges them in the direction of its motion, just as we observe a stream of water arrange the flote grass and weeds. It would require a volume to detail the different manners in which those mechanicians attempt to account for the attraction, repulsion, and polarity of magnetic bodies, by the mechanical impulsion of this fluid. Let it suffice to say, that almost every step of their theories is in contradiction to the acknowledged laws of impulsion. Nay, the whole attempt is against the first rule of all philosophical discussion, never to admit for an explanation of phenomena the agency of any cause which we do not know to exist, and to operate in the very phenomenon. We know of no such fluid; and we can demonstrate, that the genuine effects of its impulsion would be totally unlike the phenomena 47 Remarks on the theories by impulsion.

nomena of magnetiſm. But the proper refutation of theſe theories would fill volumes. Let it ſuffice (and to every logician it will abundantly ſuffice) to remark, that this phenomenon is but a ſecondary fact, depending on, and reſulting from, principles much more general, viz. the induction of magnetiſm, and the attraction of diſſimilar, and repulſion of ſimilar, poles.

The above explanation of the curious diſpoſition of iron filings round a magnet, occurred to the writer of this article while ſtudying natural philoſophy, on ſeeing the Profeſſor exhibit Mr Henſhaw's beautiful experiment in proof of terreſtrial magnetiſm*. He at that time imagined himſelf the author, and promiſed himſelf ſome credit for the thought. But having ſeen the *Phyſiologia Nova de Magnete* by Dr Gilbert, he found that it had not eſcaped the notice of that ſagacious philoſopher; as will appear paſt diſpute from the following paſſage, as well as ſome others, leſs pointed, in that work: "Magnetica fruſta (that is, ſubſtances ſuſceptible of magnetiſm) bene et convenienter intra vires poſita, mutuo cohærent. Ferramenta, preſente magnete (etiamſi magnetem non attingant), concurrunt, ſolicité ſe mutuo quærunt, et amplexantur, et, conjuncta, quaſi ferruminantur. Scobs ferrea, vel in pulverem redacta, fiſtulis impoſita chartaceis—ſupra lapidem meridionaliter locata, vel propius tantum admota, in unum coaleſcet corpus; et ſubito tam multæ partes concreſcunt et combinantur; ferrumque aliud affectat conjuratorum turma et attrahit, ac ſi unum tantum et integrum eſſet ferri baeillum; dirigiturque ſupra lapidem in ſeptemtriones et meridiem. Sed cum longius a magnete removeantur (tanquam ſoluta rurſus) ſeparantur, et diffluunt ſingula corpuſcula." B. ii. c. 23.

* See VARIATION, *Encycl.* p. 621.

Mr Æpinus alſo had taken the ſame view of the ſubject*. It is alſo very clearly conceived and expreſſed by the celebrated David Gregory, Savilian Profeſſor of aſtronomy in the Univerſity of Oxford, in a MS. volume of notes and commentaries, written by him in 1693, on Newton's *Principia*, and uſed by Newton in improving the ſecond edition. The MS. is now in the library of the univerſity of Edinburgh. Gregory's words are as follow: "Mihi ſemper dubium viſum eſt num magnetica virtus mechanicé, *i. e.* per impulſum, producatur. Mirum eſt, effluvia, quæ ferrum agitare valent, bracteas aureas *interpoſitas* ne vel minimum a loco movere. Lucretii et Carteſii theoriam, de fugato intermedio aëre, refutat experimentum infra aquam inſtitutum. *Sulci in limatura ferri, magneti in plano cujuſvis meridiani circumpoſita, non ſiunt ab effluviis ſecundum iſtos canales motis, ſed ex inde, quod ipſa ramenta, magnetice excitata, ſeſe ſecundum longitudinem et ſecundum polos diſponunt.* Ex altera vero parte exinde quod vis magnetica, interveniente flamma aut calore, interrumpatur, quod virga ferrea, vel diuturno ſitu perpendiculari, vel in eo ſitu frigeſcendo, virtutem magneticam a tellure acquirat, ut nos docet perſpicaciſſimus Gilbertus. Quod mallei ſuper incudem ictu forti ad alterum extremum, virtutem acquirat magneticam; quod ictu forti vel ſaltem fortiori ad alterum extremum poli permutantur, ut qui prius ſeptemtriones reſpiciebat nunc auſtrum reſpicit; quod ictu forti ad medium, virtutem illam prorſus amittat. Hæc inquam, et ſimilia, mechanicam ejus qualitates ortum arguunt. Hugenius, præter gravitatem, etiam magneticam, et electricam virtutem, aliaſque plures experimento novit vires naturales, ut mihi ipſi narravit hac eſtate anni 1693. Qualis ut hæc forſitan quod cymba papyracea, prope labra vaſis aquam, cui innatet, continentis, poſita, labrum viciniſſimum continuo, et cum impetu petat (A)." *Nat. MS. in Prop.* 23. ii. *Prin.*

* See § 306.

48 Filings are weakly attracted.

Not only the mere arrangement of the filings in curve lines follows of neceſſity from the properties of induced magnetiſm, but all the ſubordinate circumſtances of this phenomenon are included in the ſame explanation. By continuing to tap the table, and throw it into tremors, the filings are obſerved to approach gradually, but very ſlowly, to the poles of the magnet. Each particle is a very ſmall temporary magnet. The attractive power of the great magnet, $\overline{m-p}-\overline{n-q}$, is therefore extremely ſmall in proportion to its directive power, $\overline{m+p}-\overline{n+q}$. And we obſerve that the accumulation of the filings round the poles of the magnet is ſo much the ſlower as the filings are finer.

49 Curious fact.

If a paper be laid above the magnet, and the filings be ſprinkled on it, we obſerve them to conſtipate along its edges, while none remain immediately above its ſubſtance; they are all beyond, or on the outſide of its outline, and they are obſerved not to be lying flat on the paper, but to be ſtanding obliquely on one point. They move off from the paper immediately above the magnet, becauſe they repel each other. They ſtand obliquely from the edges, becauſe that is the direction of a magnetic meridian at its parting from the pole. If the magnet be at ſome diſtance below the paper, then tapping the paper will cauſe the filings to move away from the magnet laterally. This ſingular and unexpected appearance is owing to the combination of gravity with the magnetic action. A particle, ſuch as $n\,s$ (fig. 13.), reſts on the paper by the point n, which is a temporary north pole (S being ſuppoſed the ſouth pole of the magnet). The particle takes a poſition $n\,s$ nearer to the horizon than the poſition $n\,o$, which it would take if its centre of gravity b were ſupported. The poſition is ſuch, that its weight, acting vertically at b, is in equilibrio with the magnetic repulſion $s\,d$, exerted between S and s. When the paper is tapped, it is beaten down, or withdrawn from n, and the particle of iron is left for a moment in the air. It therefore turns quickly round b, in order to aſſume a poſition parallel to $n\,o$, and it meets the paper, as that riſes again after the ſtroke, in a point farther removed from the magnet, and again deſcends by its weight (turning round the newly ſupported point n), till it again takes a poſition parallel to $n\,s$, but farther off, as repreſented by the dotted line. Thus it travels gradually outwards from the magnet, appearing to be repelled, although it is really attracted by it. If the magnet be held above the paper, at a little diſtance, the filings, when we repeatedly pat the paper, gradually collect into a heap under it. This will appear very plainly to one who conſiders the ſituation of a particle in the manner now explained.

The

(A) Perhaps it may be proper to obſerve, that Dr Gregory expreſſes his differing in his opinion from Newton about magnetiſm. Newton, in this propoſition, thinks that the law of magnetic action approaches to the inverſe triplicate ratio of the diſtances. Dr Gregory invalidates the argument uſed by Newton.

50 ...ings ar- ...ge in ...gnetic ...ves;

The curve lines formed by very fine filings approach very nearly to the form of the primary curve which indicates the law of magnetic action in the way already explained. If the magnet be placed under water, and if filings be ſprinkled copiouſly on the ſurface of it from a gauze ſearce, held at ſome diſtance above it, the reſiſtance to their motion through the water gives them time to arrange themſelves magnetically before they reach the bottom, and the lines become more accurate. But they were ſo much deranged by any method that we could take for removing the water, and meaſuring them, that we were diſappointed in our expectations of obtaining a very near approximation to the law of action.

51 ...o in ſe- ...dary ...ves.

We took notice of ſome very ſingular phenomena of a compaſs needle in the neighbourhood of two magnets, and we obſerved that, in this caſe alſo, the needle was always a tangent to a curve of another kind, and which we called *ſecondary* and *compound magnetic curves*. Theſe are produced in the ſame way, by ſtrewing iron-filings round the magnets. Many repreſentations have been given of theſe curves by different authors, particularly by Muſchenbroeck, in his *Eſſais de Phyſique;* and by Fuſs in the *Comment. Petropolit.* Great uſe has been made of theſe arrangements of filings by two magnets in the theories of magnetiſm propoſed by thoſe who inſiſt on explaining all motion by impulſe. When the diſſimilar poles of two magnets A and B (fig. 14.) face each other, the curves formed by the filings conſiderably reſemble thoſe which ſurround a ſingle magnet, and give the whole ſomewhat of the appearance of a magnet with very diffuſed poles. The arranging fluid, which ſtreams from one pole of a magnet, is ſuppoſed to meet with no obſtruction to its entry into the adjoining pole of the other magnet, but, on the contrary, to be impelled into it; and therefore (ſay the propoſers) it circulates round both as one magnet, and by its vortex brings the magnets together; which phenomenon we call the attraction of the magnets. But when the ſimilar poles front each other; for example, the poles from which the arranging fluid iſſues, then the two ſtreams meet, obſtruct each other, accumulate, and, by this accumulation, cauſe the magnets to recede from each other; which we call the repulſion of the magnets. This is the only explanation of this kind that can make any pretenſions to probability, or indeed that can be conceived. For how the free circulation in the former caſe can bring the two magnets together, no perſon can form to himſelf any conception. We ſee nothing like this produced by any vortex that we are acquainted with. All ſuch vortices cauſe bodies to ſeparate. But even this explanation of magnetic repulſion is inadmiſſible. It will not apply to the repulſion of the receiving poles; and the phenomena of the filings are inconſiſtent with the notion of accumulation. The filings indeed accumulate, and they look not unlike two ſtreams which oppoſe each other, and deflect to the ſides (ſee fig. 15.): But, unfortunately, by tapping the paper gently, the filings do not move off from the magnets, but approach them much faſter than in any other experiment. The phenomenon receives a complete and palpable explanation from the principles we have eſtabliſhed. Both magnets concur in giving the ſame polarity to every particle of the filings. Thus, if the fronting poles are north poles, each particle has its neareſt end made a vigorous ſouth pole, and its remote end a north pole; and it is *therefore* ſtrongly attracted towards both magnets while it is arranged in the tangent to the ſecondary curve of that claſs, which croſſes the others nearly at right angles.

52 Magnets muſt affect each other.

Since it is found, that the magnetiſm, even of natural loadſtones and hard ſteel, and ſtill more thoſe of ſofter tempered ſteel, are continually tending to decay; and ſince we find that it may be induced by mere approach to a magnet; and ſince we know that magnets may oppoſe each other in producing it—it is reaſonable to ſuppoſe, that when a piece of iron has acquired a ſlight, though permanent magnetiſm, by the vicinity of a magnet, a magnet applied in the oppoſite direction will deſtroy it, and afterwards produce the oppoſite magnetiſm.

Accordingly, we may change the poles of ſoft magnets at pleaſure.

Farther; ſince we find that loadſtones and hard tempered ſteel bars are diſtinguiſhed from ſoft ones only by the *degree* of obſtinacy with which they retain their preſent condition, we ſhould alſo expect that hard magnets will even affect each other. It muſt therefore happen, that a powerful magnet applied to a weak one, ſo that their ſimilar poles are in contact, ſhall weaken, deſtroy, and even change the magnetiſm of the weaker. Dr Knight's famous magazine of magnets enabled him to change the poles of the greateſt and the ſtrongeſt natural loadſtone, or artificial magnet, that could be given him, in the ſpace of one minute.

53 Attraction muſt appear to exceed repulſion.

We now ſee clearly the reaſon why magnetic repulſion is weaker than attraction at the ſame diſtance. When magnets are placed with their ſimilar poles fronting each other, in order to make trials of their repulſion, they really do weaken each other, and are not in the ſame magnetical condition as before. For ſimilar reaſons, we ſee how experiments with magnets attracting each other rather improve them, and make their attractive powers appear greater than they are. All theſe effects muſt be moſt remarkable in ſoft magnets, eſpecially when long.

54 The obſerved law differs from the true.

We alſo ſee, that the obſerved law of attraction and repulſion between two magnets muſt be different from the real law of magnetic action. For, in the experiments made on attraction at different diſtances, beginning with the greateſt diſtance, the magnetiſm is continually increaſing, and the attraction will appear to increaſe in a higher rate than the juſt one: the contrary may happen, if we begin with the ſmaller diſtances. The reſults of experiments on repulſion muſt be ſtill more erroneous; becauſe it is eaſier to diminiſh any accumulation which required an exertion to produce it, than to puſh it ſtill farther.

55 Magnetiſm improves by inducing it on iron.

We have now a complete explanation of the remarkable fact, that the induction of magnetiſm does not weaken the magnet employed; but, on the contrary, improves it. The magnetiſm induced on the iron cauſes it to act on the magnet employed in the very ſame manner that a permanent magnet of the ſame ſhape, ſize, and ſtrength, would do. Nay, it will have even a greater effect; for as it improves the magnet, its own induced magnetiſm will improve; and will therefore ſtill farther improve the magnet.

Hence it is, that, in whatever manner a magnet touches a piece of iron, it improves by it. It may be hurt 56.

hurt by a magnet in an improper pofition; but it always puts common iron into a ftate which increafes its own magnetifm. This has been known as long as magnetifm itfelf; and the ancients conceived the notion that the magnet fomehow fed upon the iron (B).

We think that thefe obfervations authorife us to fay, that in reducing a loadftone into a convenient fhape, as much as poffible of the operation fhould be performed by grinding them with emery, in cavities made in large blocks of *hammered* iron. The magnetifm induced on the iron muft be favourable to the confervation of that in the loadftone; which, we are perfuaded, is rapidly diffipated by the tremors into which this very elaftic fubftance is thrown by the grinding with coarfe powders in any mould but iron. We imagine that the cutting off flices by the lapidaries wheel has the fame bad effect.

57. Not only will a magnet lift a greater lump of iron by its north pole, when another lump is applied to its fouth pole, but it will lift a greater piece of iron from an anvil than from a wooden table: for the magnet induces the properly difpofed polarity, not only in the iron which it lifts, but alfo in the anvil, or any piece of iron immediately beyond it. This is fo difpofed as to increafe the magnetifm of the piece of iron between them; and therefore to increafe their attraction. The magnetifm induced on the anvil is alfo in part, and perhaps chiefly, induced by the intervening iron. Thefe experiments are extremely variable in their refults.—Sometimes a fmall magnet will pull an iron wire from a large and ftrong one. Sometimes this will be done even by a piece of unmagnetic iron; and the refults appear quite capricious. But they are accurately fixed, depending on the induced compound magnetifm. Mr Æpinus has ftated fome of the more fimple cafes, in which we can tell which magnet fhall prevail. But the unfolding even of thefe cafes would take a great deal of room, and muft be omitted here. Befides, we are too imperfectly acquainted with the degree of magnetifm induced on the various parts of an iron rod, and the degree of magnetifm inherent in the various parts of the magnets, to be able to fay, with certainty, even in thofe fimple cafes, on which fide the fuperiority of attraction will remain.

58 Making of artificial magnets.

We may now proceed to deduce from this theory (for fo it may juftly be called, fince all is reduced to one fact) the procefs for communicating magnetifm to bodies fitted for receiving and retaining it; that is, the method of making artificial magnets. We fhall not employ much time on this, becaufe the moft approved methods have been delivered at length in the article Magnetism of the *Encyclopædia Britannica*; and therefore we fhall juft make fuch obfervations on them as ferve to confirm, or to perfect them by the theory. We acknowledge, that we do not know the internal procefs by which magnetifm is induced, nor even in what this magnetifm confifts. All that we know is, that the bringing the pole of a magnet near to any magnetifable matter, produces a magnetifm of the kind oppofite to that of the pole employed. We know that this is the cafe with both poles, and that it obtains at all the diftances where magnetifm is obferved. We know that the action of one pole is contrary to that of the other; that is, it counteracts the other, prevents it from producing its effect, and deftroys it when already produced: and we know that the production of thefe effects refembles, in its refult, the protrufion of fomething fluid through the pores of the body, conftipating it in all remote parts; as if the virtue of a pole refided in this moveable matter. This is nearly all that we know of it; and by thefe facts and notions we muft judge of the propriety and effect of all the proceffes for magnetifing bodies.

The moft fimple method of magnetifing a fteel bar, is to apply the north pole of a magnet to that end which we wifh to render a fouth pole. Attention to the effects of this application is very inftructive. Have in readinefs a very fmall compafs needle; turning on its pivot. It fhould not exceed half an inch in length, and fhould be as hard tempered as poffible, and ftrongly impregnated. Immediately after the application of the magnet, carry the needle along the fide of the bar. If the bar be long, and very hard, we fhall obferve a fouth polarity at the place of contact; a north polarity at a fmall diftance from it; beyond this a weak fouth polarity; then a weak and diffufed north polarity, &c.; toward the remote end the polarity will be found very uncertain. The fame thing may be difcovered by laying a ftiff paper on the bar, and fprinkling iron filings over it, and then gently tapping the paper, to make them arrange themfelves in curve lines; which will point out the various poles, and fhew whether they are diffufed or conftipated. It is very amufing and inftructive to obferve the progrefs of this impregnation. In a few minutes after the firft application of the magnet, we fhall perceive the ftate of magnetifm very fenfibly changed. The north pole will be farther from the magnet, and will be more diftinct; the fouthern polarity will alfo be protruded, and may appear for a moment at the remote extremity. The change advances; but the progrefs is more flow, and at laft is infenfible. When the bar is not harder than the temper of a cutting tool, the procefs is foon over; and if the bar is but fix or eight inches long, the remote end fhews the north polarity in a very few minutes. When the bar is very hard, the progrefs of impregnation is greatly expedited by ftriking it fo as to make it found. If it be fufpended by a ftring in a vertical pofition, and the magnet applied to its lower end, the ftriking it with a key will make it ring; and in this way make the progrefs of magnetization very quick: but it does not allow it to acquire all the magnetifm that can be given it by a very ftrong magnet.

But this is a bad way of impregnation. It is feldom that uniform magnetifm, with only two poles, and thofe of

(B) So Claudian.——" Nam ferro nurunt vitam, ferrique vigore
Vefcitur, hoc dulces epulas, hoc pabula novit
Hinc proprias renovat vires, hinc fufa per artus
Afpera fecretum fervant alimenta vigorem
Hoc abfente petit, trifti morientia torpent
Membra fame, venafque fitis confumit apertas."

Pliny fays, " Sola hæc materia (ferrum) vires ab eo lapide, accipit retinetque longo tempore, aliud apprehendens ferrum, ut annulorum catena fpectetur interdum, quod imperitum vulgus ferrum appellat vivum.

of equal ftrength, can be given. Even when there are but two, the remote pole is generally diffufed, and therefore feeble. It is much improved by employing two magnets, one at each end. And if the bar is not more than fix or eight inches long, and good magnets are employed, the magnetifm is abundantly regular. This, accordingly, is practifed for the impregnation of dipping needles, which muft not be touched, left we difturb the centre of gravity of the needle. But in all cafes, this method is tedious, and does not give ftrong magnetifm.

The method which was ufually practifed before we had obtained a pretty clear knowledge of magnetifm, was to apply the pole of a magnet to one end of the bar, and pafs it along to the other end, preffing moderately. This was repeated feveral times on both fides of the bar, always beginning the ftroke at the fame end as at firft, and, in bringing the magnet back to that end, keeping it at a diftance from the bar. The effect of this operation was to leave the end at which we began the ftroke poffeffed of the polarity of the pole employed.

A general notion of the procefs may be given as follows, obferving, however, that there occur very many great and capricious anomalies. When the north pole N (fig. 16.) of the magnet A is fet on the end C of the bar CBD, a fouth pole is produced at C, and a north pole at D, when the length of the bar is moderate. As the magnet advances flowly along the bar, the fouthern polarity at C firft increafes, then diminifhes, and vanifhes entirely when N has arrived at a certain point *a*; after which, a northern polarity appears at C, and increafes during the whole progrefs of the magnet. In the mean time, the northern polarity firft produced at D increafes till the magnet reaches a certain point *e*, then diminifhes, vanifhes when the magnet reaches a certain point *f*; after which, a fouthern polarity appears at D, which increafes till the magnet reaches D. Mr Brugmann, who firft attended minutely to thefe particulars (for Gilbert fpeaks of them pointedly), calls *a* and *f points of indifference*, and *e* the *culminating* point of the pole D, and *i* the culminating point of the pole C. Hardly can any general rule be given for the fituation of thefe points, nor even for the order in which they ftand; fo great and capricious are the anomalies in an amazing feries of experiments narrated by Brugmann and by Van Swinden. Repeating the operation, and beginning at C, the northern polarity there is weakened (fometimes deftroyed), then reftored, and continually increafed during the reft of the ftroke. The fouthern polarity at D is alfo firft weakened, and fometimes deftroyed; then reftored, and finally augmented. The points *i*, *a*, *e*, *f*, change their fituations, and frequently their order.

Van Swinden has attempted to deduce fome general laws from his immenfe lift of experiments, avoiding every confideration of a hypothefis, or the leaft conjecture by what means thefe faculties are excited. But though we have perufed his inveftigation with care and candor, we muft acknowledge, that we have not derived any knowledge which can help us to predict the refult of particular modes of treatment with any greater precifion than is fuggefted by a fort of common fenfe aided (or perhaps perverted) by a vague notion, that thefe energies refide in fomething, which avoids the pole of the fame name, carrying along with it this diftinctive energy or polarity. This conception tallies perfectly with thefe obfervations of Brugmann and Van Swinden; and admits of all the anomalies in the fituation of Bergmann's indifferent and culminating points, if we only fuppofe that this motion is obftructed by the particles of the body. We muft leave this to the reflection of the reader, who will *guefs* how, when the magnet is between C and *i*, this fubftance, avoiding the pole N of the magnet, efcapes below it, and goes toward the farther end. As the magnet advances, it drives fome of this back again, &c. &c. This is gratuitous; but it aids the fancy, which, without fome conception of this kind, has no object of fteady contemplation. We have no thought when we fpeak of the generating at C, or *a*, or *e*, a faculty of fome kind, by the exertion of the fame faculty in N. The conception is too abftracted, and much too complex. We muft content ourfelves with knowing, that N produces a fouth pole immediately under it, and a north pole everywhere elfe, or endeavours to do fo. It is unneceffary to infift longer on this method: Common fenfe fhews it to be a very judicious one.

This method was greatly improved in beginning the friction at the centre. Apply the north pole at the centre or middle of the bar, and draw it over the end intended for the fouth pole. Having done this feveral times to one end on both fides, turn the magnet, applying its fouth pole to the middle of the bar, and drawing it feveral times over the end intended for the north pole.

It was ftill more improved by employing two magnets at once, placed as in fig. 17. on the middle B of the bar, and drawing them away from each other, over the ends of it, as fhewn by the directing darts, and repeating this operation. It is plain that, as far as we underftand any thing of this matter, this procefs muft be much preferable to either of the former two. The magnets A and E certainly concur in producing a properly difpofed magnetifm on all that lies between them; and therefore on the whole bar at the end of each ftroke. The end C muft become a north, and D a fouth pole. Still, however, as the ftroke goes on to the point of indifference, each magnet tends to weaken the polarity of the parts fituated beyond it.

This method continued to be practifed till about the year 1750. Mr Canton, availing himfelf of the experiments of Mr Mitchell of Cambridge, publifhed his method by the DOUBLE TOUCH as it is called. See *Monthly Review* for 1785.

59

We need not repeat what has been detailed in the *Encyclopædia*, MAGNETISM, p. 440, &c. and fhall only make fome obfervations on the peculiar advantages of this procefs, as prefcribed by Mitchell, Canton, and improved by Mr Antheaume, in his memoir *fur les Aimans artificiels* 1766, which was crowned by the Academy of Sciences, (See alfo differtations on the fubject by *Le Maire and Du Hamel*, 1745). Method of double touch.

There is an evident propriety in the arrangement invented by Mr Mitchell, reprefented in fig. 18. The magnetifm induced on the two pieces of foft iron AD and BC is an excellent method for *fecuring* every acceffion of magnetifm to either of the bars. A good deal depends on the proper fize and length of thefe pieces; and our ignorance of the interior procefs obliges us to have recourfe to experiment alone for afcertaining this. Whatever circumftances induce the ftrongeft magnetifm on on these pieces of iron, will cause them to produce the greatest effect on the steel bars; and this will be indicated by a greater attraction. Therefore that distance will be the best which enables two bars AB and DC to lift the greatest weight hung on the piece AD or BC. When we impregnated bars whose breadth was about one tenth of their length, and their thickness about one-half of their breadth, we found, that if AD was about one fourth, or nearly one-third, of AB, they carried more than if it was either much longer or much shorter. Mr Antheaume's addition of the two great bars of iron E and F makes a sensible improvement of the *beginning* of the impregnation, when very weak magnets are employed; but did not seem to us to be of any farther service on the table. This is agreeable to any theory which can be established by what we have said hitherto.

The method of employing the magnets A and E (fig. 19), prescribed by Mitchell and Canton, is extremely judicious. The meeting of the dissimilar poles at top increases the magnetism of each. The two dissimilar poles F and G, certainly tend to give a regular and proper magnetism to the part FG of the bar which lies between them; and this is the case on whatever part of the bar they are placed. But each pole tends to destroy the present magnetism of what lies between it and the pole of the bar on that side. But mark—they tend to produce the desired magnetism on what lies between them with the *sum* of their forces; while each tends to destroy the magnetism of the part without it by the *difference* only of their forces. Therefore, on the whole, as they are moved to and fro along the bar, and the foremost one even made to pass over the end of it a little way, they always add to the magnetism already acquired. This consideration seems to enjoin setting F and G extremely near each other; for this seems to increase the sum, and to diminish the difference of their action. But it may be a question, Whether we gain more by strongly magnetising a very small part during a very short while that the magnets pass over it, or by acting on more of the bar at once, and continuing a weaker action for a longer while on this larger portion. Mr Æpinus adds another consideration depending on his notion of the internal process; but we defer this to another opportunity. The safest direction seems to be, to place them at the distance which enables them to lift the greatest weight. They are then undoubtedly acting with the greatest effect.

Mr Antheaume directs to place the touching magnets as in fig. 20. for a reason to be mentioned afterwards. Mr Æpinus also recommends it for reasons founded on his own hypothesis. We must say, that in our trials, we have found this method very sensibly superior, especially in the latter parts of the operation, when the resistance to farther impregnation becomes nearly a balance for the accumulating power of the magnets; and we consider this as no inconsiderable argument for the justice of Mr Æpinus's hypothesis.

The great advantage of this method is the regularity of the magnetism which it produces. We never find more then two poles; and when the bars are hard, and of uniform texture, the polarity is very little diffused, and seemingly confined to a very small space at the very extremities of the bar. This is indeed a prodigious advantage in point of strength. It is no less so in order to fit the magnets for experiments on the law of magnetic action; for the latitude which the diffused condition of the poles gives in the selection of the points from which the distances are to be computed, has hitherto hindered us from pronouncing on the law of magnetic action with the precision of which we think it fully susceptible. This method also is the only one by which we have been able to impregnate two bars joined end to end, considering them as one bar. We have sometimes (though very rarely) succeeded in this; so that when filings were strewed over them, the appearance could not be distinguished from a single bar.—*N. B.* Yet even in this case, in one experiment with two bars of six inches long, treated as one, when it could not be distinguished, either by the appearance of the filings, or by going round it very near with a compass needle, a very small compass needle discovered a neutral point, and a reversion of polarity similar to fig. 14. at F, shewing that it was really acting as two bars. Perhaps it must always be so; and this question is of considerable importance in the establishment of any theory of the internal process.

It deserves remark, that, in order to succeed in this attempt, a very considerable pressure is necessary. We were obliged to clean the ends of the bars very carefully, and to force the frame of bars and soft pieces of iron strongly together by wedges, in the manner of a form of types. We thought that wetting the ends of the bars with pure water aided the experiment; and we are *very certain* that oil not only greatly obstructed it, but even sensibly impeded the common process. We had put a single drop of oil on a pair of bars which we were touching in the common Cantonian method, that the magnets might be more easily drawn along them; but we were surprised at finding that we could not give a strong impregnation. The oil undoubtedly prevents the close contact. We found the finest gold leaf produce the same effect in a great degree; as also talc, of which a square inch weighed $\frac{1}{73}$th of a grain. We do not infer any thing like obstruction to the passage of something material, but rather ascribe it to mere distance; although we are of opinion, that in the impregnation of two contiguous bars, so that the magnetism (whatever it is) is disposed *precisely* as in one bar, there *is* a material transference. But we shall speak of this in its due place.

It is not unworthy of remark, that we found bars to acquire more powerful magnetism when pretty well polished than when rough. But we also found, that bars considerably rough acquired the first degrees of it much more expeditiously than those which are smooth; although we never could bring them to that high degree of magnetism that the same bars acquired after they had been polished. We think it probable, that the tremors, occasioned by the rough and harsh surfaces of the hard steel, are the causes of this phenomenon.

Some more observations on this method of the double touch will be made afterwards, when we consider the hypothesis of Mr Æpinus; and we conclude the present subject, by attempting to explain some puzzling appearances which frequently occur in making artificial magnets.

60 Difficulties explained

A bar touched by a very strong magnet has been said by Muschenbroek to be impaired by going over it with a weaker magnet. If it had been made as strong

as

as poffible, the weaker magnet, when paffed over it in the way practifed by Mufchenbroek, muft *firft* deftroy part of this magnetifm; and having done fo, it is unable to raife it anew to the fame degree of vigour.

Yet (fays Mufchenbroek with furprife) a large bar of common iron has greatly improved the magnet. A very large piece of iron *muft* do this (efpecially if fhaped like a horfefhoe, and applied with both heels), if the bar be not already at its maximum.

It was thought wonderful, that, in the method of double touch, not only was the magnetifm of the magnets employed not impaired, but, beginning with two magnets, whofe power is almoft infenfible, and repeating the operations in the precife manner defcribed by Mitchel or Canton, not only the bars intended to be made magnetical, but alfo the magnets employed, may be brought to their higheft poffible ftate of magnetifm. This is in evident conformity to the general facts of induced magnetifm, and affords the ftrongeft proof that nothing is communicated in this operation, but that powers refiding in the bars are excited, or brought into action. The manipulation merely *gives occafion* to this action, as a fpark of fire kindles a city.

61 plana- of the inning avery, ton, An- aume's cefs.

There ftill remain fome circumftances of this method, as practifed by Savery, Canton, and Antheaume, which are extremely curious and important.

Mr Savery had obferved a fmall bit of fteel acquire very fenfible magnetifm by lying long in contact with the lower end of a great window bar. Telling this to a friend, he was, for the firft time, informed, that this had been long obferved, and that Dr Gilbert had made fome curious inferences from it. Mr Savery wanted fome magnets, and was at a diftance from town. Reflecting, like a philofopher, on what he had heard and obferved, he faw here a fource of magnetifm which he could increafe, in the manner commonly practifed in making magnets. He placed the bar AB (fig. 21.) to be magnetifed between two great bars of common iron C and D, placing all the three in the magnetical direction. He took another bar EF, and put two little pieces of iron, like the armour of a loadftone, on its ends: and with thefe ends he rubbed the bar AB, rubbing the upper half of it with the end F, and the lower with the end E. The refult of this was a very brifk magnetifm in a few minutes, which, by various well devifed alternations, he brought it to its higheft degree. His numerous experiments publifhed in the philofophical Tranfactions in 1746, contain much curious information, highly deferving the attention of the philofophers. Mr Canton, proceeding on the fame principle, that bars of iron, which have been long in a vertical pofition, acquire an efficient magnetifm, begins his operations by placing his fteel bar on the head of a kitchen poker, and rubs it with the lower end of a pair of kitchen tongs. Mr Antheaume adheres more ftrictly to the inferences from the principle of terreftrial magnetifm, and repeats precifely the previous difpofition of things practifed by Mr Savery, placing his little fteel bar AB (fig. 22.) between two great bars C and D of common iron, and arranging the whole in the magnetic direction. Then, proceeding moft judicioufly on the fame principle, he greatly improves the procefs, by employing two bars EF and GH for the touch, holding them about an inch apart, inclined about 15° to the bar AB. It is plain, that the lower end of each of thefe five bars is a north pole, and the upper end a fouth pole. Therefore the poles F and G concur in giving the proper magnetifm to the portion FG of the fteel bar which is between them; and by rubbing it with thefe poles up and down, overpaffing each extremity about half an inch, he muft foon give to the bar AB a regular magnetifm; weak, perhaps, but to be afterwards increafed in the Cantonian method, on a horizontal table. In this manner did Mr Antheaume make magnets of very great ftrength in 1766. See his *Differtation* already quoted.

62 Gilbert's terreftrial magnetifm.

Thefe obfervations naturally bring us to the PHYSIOLOGIA NOVA DE MAGNET ET CORPORIBUS MAGNETICIS of Dr Gilbert; a difcovery which the fagacious Kepler claffes among the greateft in the annals of fcience.

It could not be that a phenomenon fo general, and fo interefting and important as the natural polarity of magnetic bodies, would be long known without exciting curiofity about its caufe. Accordingly the philofophers of the 16th century fpeculated much about it, and entertained a variety of opinion, if that can be called an opinion which can hardly be faid to exprefs a thought. We have in *Marfigli Ficino* a fhort notice of many of thefe opinions. Some maintained that the needle was directed by a certain point in the heavens, as if that were faying more than that it always pointed one way. Others, with more appearance of reafoning, afcribed the direction to vaft magnetic rocks. But all this was without giving themfelves the trouble of trying to afcertain what fituation of fuch rocks would produce the direction that is obferved. Fracafteri was, if we miftake not, the firft who thought this trouble at all neceffary; and he obferves very fenfibly, that if thofe rocks are fuppofed to be in any place yet vifited by navigators, and if they act as loadftones do (a circumftance which he fays muft be admitted, if we attempt to explain), the direction of the needle will be very different from what we know it to be. He therefore places them in the inacceffible polar regions, but not in the very pole. Norman, the difcoverer of the dip of the mariner's needle, or of the true magnetic direction, was naturally led by his difcovery to conceive the directing caufe as placed in the earth; becaufe the north point of the needle, in every part of Europe, points very far below the horizon. But although he calls the treatife in which he announces his difcovery the *New Attractive*, he does not exprefs himfelf as fuppofing the needle to be attracted by any point within the earth, but only that it is always directed to that point.

It is to Dr Gilbert of Colchefter that we owe the opinion now univerfally admitted, that magnetic polarity is a part of the conftitution of this globe. Norman had, not long before, difcovered, that if a fteel needle be very exactly balanced on a horizontal axis, like the beam of a common balance, fo that it would retain any pofition given it, and if it be then touched with a magnet, and placed on its axis in the magnetic merdian, it is no longer in equilibrio, but at (at London) the north point of it will dip 72 or 73 degrees below the horizon. He did not, however, publifh his difcovery till he had obtained information how it ftood in other parts of the world. The differences in the variation in different places naturally fuggefted the neceffity of this to him. Being a maker of mariners compaffes, paſſes, and teacher of navigation in London, he had the faireſt opportunities that could be deſired, by furniſhing dipping needles to ſuch of the navigators, his ſcholars, as he knew moſt able to give him good information. And the accounts which he received made his diſcovery, when announced to the world, a very complete thing; for the commanders of ſhips engaged in long voyages, and particularly to China, informed him that, in the vicinity of the equator, his dipping needles remained parallel to the horizon, but that in coming toward the north pole, the north end of the needle was depreſſed, and that the ſouth end dipped in like manner at the Cape of Good Hope, and in the Indian Ocean; that the needle gradually approached the horizontal poſition as the ſhip approached the equator, but that in coming to the north of it at Batavia, the north point again dipped, and at Canton was ſeveral degrees below the horizon.

On theſe authorities, Norman boldly ſaid that, in the equatorial regions, the needle was horizontal, and that either end dipped regularly as it approached either pole; and that in the poles of the earth, the needle was perpendicular to the horizon. He therefore announced this as a diſcovery, not only ſingularly curious, but alſo of immenſe importance; for by means of a dipping needle the latitude of a ſhip at ſea may be found without ſeeing the ſun or ſtars.

Dr Gilbert, comparing this poſition of the compaſs needle with the poſitions which he had obſerved ſmall needles aſſume in his numerous experiments in relation to a magnet, as we have deſcribed at great length, was naturally led to the notion of the earth's being a great loadſtone, or as containing one, and that this arranged the dipping, or, in general, the mariner's needle, in the ſame manner as he obſerved a great magnet arrange a ſmall needle poiſed on its pivot. He therefore compoſed his *Phiſiologia Nova de Magnete*, et *de Tellure magno Magnete*; in which he notices ſo many points of reſemblance to the directive power of a magnet, that the point ſeems no longer to admit of any doubt. Dr Gilbert's theory may be thus expreſſed:

All the phenomena of natural magnetiſm are analogous to what we ſhould obſerve, if the earth were a great magnet, having its poles near the poles of the earth's equator, the north pole not far from Baffin's Bay, and the ſouth pole nearly in the oppoſite part of the globe. A dipping needle, under the influence of this great magnet, muſt arrange itſelf in a plane which paſſes through the poles of the magnet, the poſition of which plane is indicated (at leaſt nearly) by the ordinary compaſs needle; and it will be inclined to the horizon ſo much the more as we recede from the equator of the great magnet.

This opinion of Dr Gilbert was not leſs ingenious than important; and if firmly eſtabliſhed, it furniſhes a complete theory of all the phenomena of magnetiſm. But obſervations were neither ſufficiently numerous in the time of Dr Gilbert, nor ſufficiently accurate, to enable that great genius to aſſign the poſition of this great magnet, nor the laws of its action. The theory was chiefly founded on the phenomena of the dipping needle; phenomena which might have been unknown for ages, had the firſt notice of them fallen into any other hands than Norman's. They are not, like thoſe of variation, which might be made by any ſailor. They require for their exhibition a dipping needle, and the attention to circumſtances which can occur only to a mathematician. A dipping needle is to this day, notwithſtanding all our improvements in the arts, one of the moſt delicate and difficult taſks that an inſtrument maker can take in hand, and a good one cannot be had for leſs than twenty guineas. We are confident that ſuch as even Norman could make were far inferior to what are now made, and quite unfit for uſe at ſea while the ſhip is under ſail, although they may be tolerably exact for an obſervation of the dip in any port; and we preſume that it was ſuch obſervations only that Norman confided in. Our readers will readily conceive the difficulty of poiſing a needle with ſuch a perfect coincidence of its centre of gravity and axis of motion, and perfect roundneſs of this axis, that it ſhall remain in any poſition that is given it. Add to this, that a grain of duſt, inviſible to the niceſt eye, getting under one ſide of this axis, may be ſufficient for making it aſſume another poſition. It muſt alſo be a difficult matter to preſerve this delicate thing, ſo as that no change can happen to it. Beſides, all this muſt be performed on a piece of tempered ſteel which we are certain has no magnetiſm. Where can this be got, or what can inſure us againſt magnetiſm? Nor is there leſs difficulty in making the obſervations without great riſk of error. If the needle, moveable only in a vertical plane, be not ſet in the plane of a magnetic meridian, it will always dip too much. At London, where the magnetic direction is inclined 73° to the horizon, if it be in a plane 20° from the magnetic meridian, it will ſtand almoſt perpendicular; for it is eaſy to ſee, by the mechanical reſolution of forces, that it will take the poſition which brings it neareſt to the true magnetic direction. This, we think, is confirmed by ſeveral of Norman's and other old obſervations of dip. They are much greater than they have been ſince found in the ſame places.

Mr Daniel Bernoulli has given a very ingenious principle, by which we can make a dipping needle which will give a very accurate obſervation on ſhore; and being ſo eaſily executed, it deſerves to be generally known. Let a dipping needle be made in the beſt manner that can be done by a workman of the place, and balanced with ſome care before impregnation, ſo that we may be certain that when touched it will take nearly the true dip. Touch it, and obſerve the dip. Deſtroy its magnetiſm, and then alter its balance in ſuch a manner that, without any magnetiſm, it will arrange itſelf in the inclination of the obſerved dip. Now touch it again, giving it the ſame poles as before. It is plain that it will now approach exceedingly near indeed to the true dip, becauſe its want of *perfect* equilibrium deranged it but a few degrees from the proper direction. If this ſecond obſervation of the dip ſhould differ ſeveral degrees from the firſt, by the inaccurate firſt formation of the needle, it will be proper to repeat the operation. Very rarely, indeed, will the third obſervation of the dip vary from the truth half a degree.

63 Daniel Be[r]noulli's d[ip]ping nee[dle]

Mr Bernoulli makes this ſimple contrivance anſwer the purpoſe of an univerſal inſtrument in the following ingenious manner. A very light braſs graduated circle EFG (fig. 23.) is fixed to one ſide of the needle, concentric with its axis, and the whole is balanced as nicely as poſſible before impregnation. A very light index CD

CD is then fitted on the axis, ſo as to turn rather ſtiffly on it. This will deſtroy the equilibrium of the needle. If the needle has been made with perfect accuracy, and perfectly balanced, the addition of this index would cauſe it always to ſettle with the index perpendicular to the horizon, whatever degree of the circle it may chance to point at. But as this is ſcarcely to be expected, ſet the index at various degrees of the circle, and note what inclination the unmagnetic needle takes for each place of the index, and record them all in a table. Suppoſe, for example, that when the index is at 50, the needle inclines 46° from the horizon. If in any place we obſerve that the needle (rendered magnetic by lying between two ſtrong magnets), having the index at 50, inclines 46°, we may be certain that this is the dip at that place; for the needle is not deranged by the magnetiſm from the poſition which gravity alone would give it. As we generally know ſomething of the dip that is to be expected in any place, we muſt ſet the index accordingly. If the needle does not ſhew the expected dip, alter the poſition of the index, and again obſerve the dip. See whether this ſecond poſition of the index and this dip form a pair which is in the table. If they do, we have got the true dip. If not, we muſt try another poſition of the index. Noticing whether the agreement of this laſt pair be greater or leſs than that of the former pair, we learn whether to change the poſition of the index in the ſame direction as before, or in the oppoſite. The writer of this article has a dipping needle of this kind, made by a perſon totally unacquainted with the making of philoſophical inſtruments. It has been uſed at Leith, at Cronſtadt in Ruſſia, at Scarborough, and at New York, and the dip indicated by it did not in any ſingle trial differ $1\frac{1}{2}$ degrees from other trials, or from the dip obſerved by the fineſt inſtruments. He tried it himſelf in Leith Roads, in a rough ſea; and does not think it inferior, either in certainty or diſpatch, to a needle of the moſt elaborate conſtruction. It is worthy of its moſt ingenious author, and of the public notice, becauſe it may be made for a moderate expence, and therefore may be the means of multiplying the obſervations of the dip, which are of immenſe conſequence in the theory of magnetiſm, and for giving us an accurate knowledge of the magnetical conſtitution of this globe.

64 Opinions concerning the great magnet contained in this globe.

This knowledge is ſtill very imperfect, owing to the want of a very numerous collection of obſervations of the dip. They are of more importance than thoſe of the horizontal deviations from the meridian. All that we can ſay is, that the earth acts on the mariner's needle as a great loadſtone would do. But we do not think that the appearances reſemble the effects of what we would call a good loadſtone, having the regular magnetiſm of two vigorous poles. The dips of the needle in various parts of the earth ſeem to be ſuch as would reſult from the action of an extremely irregular loadſtone, having its poles exceedingly diffuſed. The increaſe of the dip, as we recede from thoſe places where the needle is horizontal, is too rapid to agree with the ſuppoſition of two poles of conſtipated magnetiſm, whether we ſuppoſe the magnetic action in the inverſe ſimple or duplicate ratio of the diſtances, unleſs the great terreſtrial magnet be of much ſmaller dimenſions than what ſome other appearances oblige us to ſuppoſe. If there be four poles, as Dr Halley imagined, it will be next to impoſſible to aſcertain the poſitions of the dipping needle. It will be a tangent to one of the ſecondary magnetic curves, and theſe will be of a very intricate ſpecies. We cannot but conſider the diſcovery of the magnetic conſtitution of this globe as a point of very great importance, both to the philoſopher and to ſociety. We have conſidered it with ſome care; but hitherto we have not been able to form a ſyſtematic view of the appearances which gives us any ſatisfaction. The well informed reader is ſenſible, that the attempt by means of the horizontal or variation needle is extremely tedious in its application, and is very unlikely to ſucceed; at the ſame time it muſt be well underſtood. The two diſſertations by Euler, in the 13th and 22d volumes of the Memoirs of the Royal Academy at Berlin, are moſt excellent performances, and give a true notion of the difficulty of the ſubject. Yet, even in theſe, a circumſtance is overlooked, which, for any thing we know to the contrary, may have a very great effect. If the magnetic axis be far removed from the axis of revolution, as far, for example, as Mr Churchman places it, the magnetic meridians will be (generally) much inclined to the horizon; and we ſhall err very far, if we ſuppoſe (as in Euler's calculus) that the dipping needle will arrange itſelf in the verticle plane, paſſing through the direction of the horizontal or variation needle; or if we imagine that the poles of the great magnet are in that plane. We even preſume to think that Mr Euler's aſſumption of the place of his fictitious poles (namely, where the needle is vertical), in order to obtain a manageable calculus, is erroneous. The introduction of this circumſtance of inclination of the magnetic meridians to the horizon, complicates the calculation to ſuch a degree as to make it almoſt unmanageable, except in ſome ſelected ſituations. Fortunately, they are important ones for aſcertaining the places of the poles. But the inveſtigation by the poſitions of the dipping needle is incomparably more ſimple, and more likely to give us a knowledge of a multiplicity of poles. The conſideration of the magnetic curves (in the ſenſe uſed in the preſent article), teaches us that we are not to imagine the poles immediately under thoſe parts of the ſurface where the needle ſtands perpendicular to the horizon, nor the magnetic equator to be in thoſe places where the needle is horizontal; a notion commonly and plauſibly entertained. Unfortunately our moſt numerous obſervations of the dip are not in places where they are the moſt inſtructive. A ſeries ſhould be obtained, extending from New Zealand northward, acroſs the Pacific Ocean to Cape Fairweather on the weſt coaſt of North America, and continued through that part of the continent. Another ſeries ſhould extend from the Cape of Good Hope, up along the weſt coaſt of Africa to the tropic of Capricorn; from thence acroſs the interior of Africa (where it would be of great importance to mark the place of its horizontality) through Sicily, Italy, Dalmatia, the eaſt of Germany, the Gulph of Bothnia, Lapland, and the weſt point of Greenland. This would be nearly a plane paſſing through the probable ſituations of the poles. Another ſeries ſhould be made at right angles to this, forming a ſmall circle, croſſing the other near Cape Fairweather. This would paſs near Japan, through Borneo, and the weſt end of New Holland; alſo near Mexico, and a few degrees weſt of Eaſter Iſland. In this place, and at Borneo, the

See VARIATION, Encycl.

the inclination of the magnetic plane to the horizon would be confiderable, but we cannot find this out. It may, however, be difcovered in other points of this circle, where the dip is confiderable. We have not room in this fhort account to illuftrate the advantages derived from thefe feriefes; but the reflecting reader will be very fenfible of them, if he only fuppofes the great magnet to be accompanied by its magnetic curves, to which the needle is always a tangent. He will then fee that the firft feries from New Zealand to Cape Fairweather, and the fecond from Cape Fairweather round the other fide of the globe, being in one plane, and at very different diftances from the magnetic axis, muft contain very inftructive pofitions of the needle. But we ftill confefs, that when we compare the dips already known with the variations, they appear fo irreconcileable with the refults of an uniform regular magnetifm, that we defpair of fuccefs. Every thing feems to indicate a multiplicity of poles, or, what is ftill more adverfe to all calculation, an irregular magnetifm with very diffufed polarity.

Much inftruction may furely be expected from the obfervations of the Ruffian academicians and their eleves, who are employed in furveying that vaft empire; yet we do not meet with a fingle obfervation of the dip of the needle in all the bygone publications of that academy, nor indeed are there many of the variation.

65 And concerning the fituation of its poles.

For want of fuch information, philofophers are extremely divided in their opinions of the fituation of the magnetic poles of this globe. Profeffor Krufft, in the 17th volume of the Peterfburgh Commentaries, places the north pole in lat. 70° N. and long. 23° W. from London; and the fouth pole in lat. 50° S. and long. 92° E.

Wilcke of Stockholm, in his indication chart (*Swed. Mem.* tom. xxx. p. 218.), places the north pole in N. Lat. 75°, near Baffin's Bay, in the longitude of California. The fouth pole is in the Pacific Ocean, in lat. 70° S.

Churchman places the north pole in lat. 59° N. and long. 135° W. a little way inland from Cape Fairweather; and the fouth pole in lat. 59° S. Long. 165° E. due fouth from New Zealand.

A planifphere by the Academy of Sciences at Paris for 1786, places the magnetic equator fo as to interfect the earth's equator in long. 75°, and 155° from Ferro Canary Ifland, with an inclination of 12 degrees nearly, making it a great circle very nearly. But we are not informed on what authority this is done; and it does not accord with many obfervations of the dip which we have collected from the voyages of feveral Britifh navigators, and from fome voyages between Stockholm and Canton. Mr Churchman has given a fketch of a planifphere with lines, which may be called parallels of the dip. Thofe parts of each parallel that have been afcertained by obfervation are marked by dots, fo that we can judge of his authority for the whole conftruction. It is but a fketch, but gives more fynoptical information than any thing yet publifhed. The magnetic equator cuts the earth's equator in long. 15°, and 195° E. from Greenwich, in an angle of nearly 17 degrees. The circles of magnetic inclination are not parallel, being confiderably nearer to each other on the fhort meridian than on its oppofite. This circumftance, being founded on obfervation, is one of the ftrongeft arguments for the exiftence of a magnet of tolerable regularity, as the caufe of all the pofitions of the compafs needle; for fuch *muft* be the pofitions of the circles of equal dip, if the axis of this magnet is far removed from the axis of rotation, and does not interfect it.

66. Now, if the fituation of the poles be any thing near the average or medium of thefe determinations, and if we form all our notions by analogy, comparing the pofitions of the compafs needle in relation to the great terreftrial magnet, with the pofitions affumed by a fmall needle in the neighbourhood of a magnet, we muft conclude, that the magnetical conftitution of this globe has little or no reference to its regular external form. The axis of the magnet is very far removed from that of the globe (at leaft 1500 miles), and is not nearly parallel to it, nor in the fame plane. It required the fagacity and the fkill of a Euler to fubject fuch anomalous magnetifm to any rules of computation; and every perfon qualified to judge of the fubject muft allow his differtation in the 13th volume of the Berlin Memoirs to be a work of wonderful refearch. It is a very agreeable thing to fee fuch a conformity between the lines which exprefs the regular magnetifm of Euler's differtation, and the lines drawn by Dr Halley from obfervation, and which appeared to himfelf fo capricious, that he defpaired (notwithftanding his confummate fkill in geometry) of their ever being reduced to a mathematical and precife fyftem.

67 Confirmations of Dr Gilbert's phyfiology.

Without detracting from the merit of Dr Gilbert, we may prefume to fay that his notion of the earth's being a great magnet was not, in his mind, more than a fagacious conjecture, formed from a very general and even vague comparifon. Yet the comparifon was fufficiently good to give him great confidence in his opinion that the action of this great magnet, in perfect conformity to what we obferve in our experiments with magnets, is the fource of all the magnetifm that we obferve. If there was nothing elfe in proof of the juftnefs of his theory, it is abundantly proved by the beautiful experiment of Mr Henfhaw, mentioned in the article VARIATION, *Encycl.* p. 621. col. 2. An iron bar held nearly upright, attracts the fouth end of a compafs needle with its lower end; and if that end of the bar be kept in its place, and the bar turned round till it becomes the upper end, the fouth point of the needle immediately turns away from it, and the north end is now attracted. This experiment may be perfectly imitated with artificial magnetifm.

Having fupported a large magnet SAN (fig. 24.), fo that its ends are detached from furrounding bodies, place a fmall needle B (poifed on its pivot) about three inches below the north pole N of the magnet, and in fuch a fituation that its polarity to the magnet may be very weak. Take now a fmall piece of common iron, and hold it in the pofition reprefented at C. Its lower end becomes a north pole, attracting the fouth pole of the needle. Keeping this in its place, turn round the piece of iron into the pofition D; the fouth pole of B will now avoid it, and the north pole will be attracted. We directed the needle to be fo placed, that its polarity, in relation to the magnet, may be weak. If it be ftrong, it may act on the end of C or D like a magnet, and counteract the magnetifm induced on C or D by vicinity to A.

An

An anonymous writer in the Philosophical Transactions, No 177. Vol. XV. relates several observations made during a voyage to the East Indies, which are quite conformable to this. A few leagues northwest from the island Ascension, the south point of the compass needle hardly shewed any tendency to or from the lower end of an iron bar. It seemed rather to avoid the upper end; it was not in the least affected by the middle of the bar; but when the bar was laid horizontal, in the magnetic direction, its two ends affected the dissimilar ends of the compass needle very strongly; but when horizontal, and lying at right angles to the magnetic direction, its polarity was altogether indifferent.

As the other phenomena of induced artificial magnetism have the same resemblance to the phenomena of natural magnetism, a bar which has remained long in the vicinity of a magnet acquires magnetism (permanent) in the same way, and modified by the same circumstances, as in natural magnetism. Hammering a bit of common iron in the immediate vicinity of a magnet, gives it very good magnetism. Exposing a red hot bar to cool in the neighbourhood of a magnet has the same effect. Also quenching it suddenly has the same effect. Quenching a small red hot steel bar between two magnets, was found by us to communicate a much stronger magnetism than we could give it by any other method. Its form indeed was very unfavourable for the ordinary method of touching; for it consisted of two little spheres connected by a slender rod, and could scarcely be impregnated in any other way than by placing it for a very long while between magnets. In all these experiments, the polarity acquired is precisely similar to that acquired by the same treatment in relation to this supposed great terrestrial magnet. In short, in whatever manner we pursue this analogy in our experiments, we find the resemblance most perfect in the phenomena.

We cannot but think, therefore, that this new physiology of the magnet by Dr Gilbert is well established; and we think ourselves authorised to assume it as a proposition fully demonstrated, that the earth is a great magnet, or contains a great magnet, the agency of which produces the direction of the magnetic needle, and all the magnetism which iron acquires by long continuance in a proper position. It is this which made us say, in the beginning of this article, that attraction and polarity were not confined to magnets, but were properties belonging to all iron in its metallic state. We now see the reason why any piece of iron brought very near to another piece will attract it—both become magnetical, in consequence of the agency of the great magnet; and their magnetism is so disposed, that their mutual attractions exceed their repulsions. Also, why an iron rod, placed nearly in the magnetical direction, will finally arrange itself in that direction. Also, why the terrestrial polarity of common iron is indifferent, and either end of the rod will settle in the north, if it have nearly that position at first. The magnetism induced by mere momentary position is so feeble as to yield to any artificial magnetism. As a moment was sufficient for imparting it, a moment suffices for destroying it; and another moment will impart the opposite magnetism. But artificial magnetism requires more force for its production, and some of it remains when the producing cause is removed, and it does not yield at once to the contrary magnetism. That there is no farther difference appears from this, that long continued position gives determined and permanent magnetism, and that it is destroyed by an equally long continuance in the contrary position. It seems to be very generally true, that a magnet will carry more by its north than by its south pole. It should be so in this part of the world, because the terrestrial magnetism induced on the iron conspires with the magnetism induced by the north pole of a magnet, but counteracts the magnetism induced by the south pole.

The propriety of Mr Savery's, Mr Canton's, and Mr Antheaume's processes for beginning the impregnation of hard steel bars is now plain, and the superior effect of the two great bars of common iron in the proposed method of Mr Antheaume. We cannot but take this opportunity of paying the proper tribute of praise to the ingenuity of Mr Savery. Every circumstance of his process was selected in consequence of an accurate conception of magnetism, and the combination of this science with Dr Gilbert's theory. His process is the same with Antheaume's in every respect, except the circumstance of the double touch borrowed from Mitchell and Canton. These observations do not detract from the discernment of Mitchell and Canton, who saw in those experiments what had escaped the attention of hundreds of readers.

68 Seeming objection deduced from the want of sensible attraction.

But there occurs an objection to this theory of Dr Gilbert, which was urged against it with great force. We observe no tendency in the magnet or compass needle toward this supposed magnet. An iron or steel bar is not found to increase its tendency downwards, that is, is not sensibly heavier, when its south pole is uppermost in this part of the world. A needle set afloat on a piece of cork arranges itself quickly in the proper direction; but if continued ever so long afloat, it has never been observed to approach the north side of the vessel. This is quite unlike what we observe in the mutual actions of magnets, or the action of magnets on iron. This objection appears to have given Dr Gilbert some concern; and he mentions many experiments which have been tried on purpose to discover some magnetical tendency. He gets rid of it as well as he can, by saying that the directive power of a magnet extends much farther than its attractive power. He confirms this by several experiments. But Dr Gilbert had not studied the simultaneous actions of the four poles, nor explained, by the principles of compound motion, how these produced all the possible positions of the needle. Indeed, the composition of mechanical forces was by no means familiar with philosophers at the end of the 16th century. We see it now very distinctly. The polarity of the needle, or the force with which it turns itself into the magnetical position, depends on the difference between the *sums* of the actions of each pole of the magnet on both the poles of the needle; whereas its tendency towards the magnet depends on the difference of the *differences* of those actions (see n° 22, 25.) The first may thus be very great when the other is almost insensible. We see that coarse iron filings heap about the magnet very fast, and that very fine filings approach it very slowly. Now, the largest magnet that we can employ, when compared with the great magnet in the earth, is but as a particle of the finest filings that can be conceived. This surely diminishes exceedingly, if it does not entirely annihilate the objection: but as we have heard it urged by many as an improbable thing, that a long magnet, kept afloat for many months (which has been done) ſhall not ſhew the *ſmalleſt* tendency towards the pole of the terreſtrial magnet, we think it deſerves to be conſidered with accuracy, and the queſtion decided in a way which will admit of no doubt.

69 This completely anſwered.

Let the very ſmall magnet C (fig. 25.) be placed near a great magnet A, and then near a ſmaller magnet B, in ſuch a manner that its polarity to both ſhall be the ſame; and then let us determine the proportion between the attractions of A and B for the ſmall magnet C.

This will evidently depend on the law of magnetic action. For greater ſimplicity of inveſtigation, we ſhall content ourſelves with ſuppoſing the action to be inverſely as the diſtance.

Let AN, = AS, $=a$; BN $=b$; Cn $=c$, AC $=d$, BC $=\delta$; and let the abſolute force of A be to that of B at the ſame diſtance as m to 1.

The magnetic action being ſuppoſed proportional to $\frac{1}{d}$, we have,

1. Action of AN on Cs $= \frac{m}{d-a-c}$.

2. ——— AN on Cn $= -\frac{m}{d-a+c}$.

3. ——— AS on Cs $= -\frac{m}{d+a-c}$.

4. ——— AS on Cn $= \frac{m}{d+a+c}$.

5. The whole action $= \dfrac{8\,m\,a\,c\,d}{\overline{d^2-\overline{a+c}^2}\,|^2 \times \overline{d^2-\overline{a-c}^2}\,|^2}$.

6. If c be very ſmall in compariſon with a or b, the whole action of A is very nearly $= \dfrac{8\,m\,a\,c\,d}{\overline{d^2-a^2}^2}$.

7. And the tendeney of C to B is, in like manner, $= \dfrac{8\,b\,c\,\delta}{\overline{\delta^2-b^2}^2}$.

The directive powers of A and B are at their maximum ſtate when C is placed with its axis at right angles to the lines AC or BC. In which caſe we have,

8. The directive power of A $= \dfrac{4\,m\,a}{d^2-a^2}$.

9. The directive power of B $= \dfrac{4\,b}{\delta^2-b^2}$.

When theſe directive powers are made equal, by placing C at the proper diſtances from A and B, we have,

10. $4\,m\,a : 4b$, or $m\,a : b = d^2-a^2 : \delta^2-b^2$

And $m\,a\,\delta^2 - m\,a\,b^2 = b\,d^2 - b\,a^2$

$m\,a\,\delta^2 = b\,(d^2-a^2) + m\,a\,b^2$.

11. $\delta^2 = \dfrac{b}{m\,a}(d^2-a^2) + b^2$.

12. $\delta = \sqrt{\dfrac{b}{m\,a}(d^2-a^2) + b^2}$.

Let the attractions of A and B for the very ſmall magnet C, when its polarity to both is the ſame, be expreſſed by the ſymbols α and β. We have

$\alpha : \beta = \dfrac{8\,m\,a\,c\,d}{(d^2-a^2)^2} : \dfrac{8\,b\,c\,\delta}{(\delta^2-b^2)^2}$, which, by n° 10. is $= \dfrac{8\,(d^2-a^2)\,c\,d}{(d^2-a^2)^2} : \dfrac{8\,(\delta^2-b^2)\,c\,\delta}{(\delta^2-b^2)^2} = \dfrac{d}{d^2-a^2} : \dfrac{\delta}{\delta^2-b^2}$, $= b\,d : m\,a\,\delta$; that is,

13. Attr^n of A : attr^n of B $= b\,d : m\,a\,\delta$.

As an example of this compariſon, let us ſuppoſe the great terreſtrial magnet to be a thouſand times larger and ſtronger than the magnet whoſe attraction we are comparing with that of terreſtrial magnetiſm. Let us alſo ſuppoſe the diſtance from the pole of the great magnet to be ſmall, ſo that its attraction may be conſiderable. Let us make $d = 1200$, a being $= 1000$, and $b = 1$. Theſe are all very reaſonable ſuppoſitions. Subſtituting theſe values in the formula, we have attr^n of A : attr^n of B $= 1 : 1000$ very nearly; and therefore when the needle, when placed near a magnet, vibrates by its polarity as faſt as it does by natural magnetiſm, its tendency toward that magnet muſt be altogether inſenſible; for the diſproportion is incomparably greater than that of 1 to 1000, in the largeſt magnets with which we can make experiments. Obſerve alſo, that we have taken the caſe where the attractions are the ſtrongeſt, viz. when the magnet C is placed in the axis of A or B. In the oblique poſitions, tangents to the magnetic curves, the attractions are ſmaller, almoſt in any ratio.

We took the inverſe ratio of the diſtances for the law of action, only becauſe the analyſis was very ſimple. It is very evident that the diſproportion will be ſtill more remarkable, if the action be inverſely as the ſquare of the diſtance.

The objection therefore to the origin of the polarity of the compaſs needle, and of all other magnets, namely, the action of a great magnet contained in the earth, appears plainly to be of no force. We rather think that the want of all ſenſible attraction, where there is a briſk polarity, is a proof of the juſtneſs of the conjecture; for if the compaſs needle were arranged by the action of magnetic rocks, or even extenſive ſtrata, near the ſurface of the earth, the attractions would bear a greater proportion to the polarities. We have even obſerved this. A conſiderable maſs of magnetic ſtratum was found to derange the needle of a ſurveyor's theodolite at a conſiderable diſtance all around (about 140 yards). The writer placed the needle on a thin lath, which juſt floated it on water in a large wooden diſh, and ſet it in a place where it was drawn about 15 degrees from the magnetic meridian. It was left in that ſituation a whole night, well defended from the wind by a board laid on the diſh. Next morning it was found applied to that ſide of the diſh which was neareſt to the diſturbing rocks. It had moved about ſix inches. This was repeated three times, and each time it moved in the ſame direction (nearly), which differed conſiderably from the direction of the needle itſelf.

It is now plain that we may, with confidence, aſſume Dr Gilbert's theory of terreſtrial magnetiſm as ſufficiently eſtabliſhed. And, ſince we muſt certainly call that the north pole of the great magnet which is ſituated in the northern parts of the earth, and ſince thoſe poles of magnets which attract each other have oppoſite polarities, we muſt ſay, that what we call the north pole of a mariner's needle, or of any other magnet, has the ſouthern polarity.

We may now venture to go farther with Dr Gilbert, and

70 The great magnet is the source of all natural magnetism.

and to say that *all* the magnetism which we observe, whether in nature or art, is either the immediate or the remote effect of the action of the great magnet. As soft bars soon acquire a transient magnetism; as hard bars, after long exposure, acquire a sensible and permanent magnetism—we must infer, that ores of iron, which are in a state fit for impregnation, must acquire a sensible and permanent magnetism, by continuing, for a series of ages, in the bowels of the earth. And thus the magnetism of loadstones, which, till the discovery of the natural magnetism acquired by position, were the sources of all our magnetical phenomena, is now proved to be a necessary consequence of the existence and agency of a great magnet contained in the bowels of the earth.

71 Loadstones in the mine may have their poles in any position.

It seems to result from this theory, that, in these northern parts of the world, that part of every natural loadstone that is at the extremity of the line drawn through the stone in the magnetic direction should be its pole; and that the loadstone, when properly poised, should of itself assume the very position which it had in the mine. Dr Gilbert complains of the inattention of miners (*rude hominum genus, lucro potius quam physicæ consulentes*) to this important circumstance. Once, however, he had the good fortune to be advertised of a great magnetic mass lying in its matrix. He repaired quickly to the mine, examined it, and marked its points which were in the extremities of the magnetic line. When it was detached from its matrix, he had the pleasure of finding its poles in the very places he expected. The loadstone was of considerable size, weighing about 20 pounds.—Mr Wilcke gives, in the Swedish Commentaries, several instances of the same kind.

But should this always be the case? By no means. There are many circumstances which may give the magnetism of a loadstone a very different direction. We have found, that simple juxtaposition to a magnet will sometimes give a succession of poles to a long bar of hard steel. The same thing may happen to an extensive vein of magnetisable matter. The loadstone taken out of this vein may have been placed like that of a soft bar placed in the magnetic line, if lying in one part of the vein; if taken from another part of it, its polarity may be the very reverse; and in another part of it may have no magnetism, although completely fitted for acquiring it. It may have its poles placed in a direction different from all these, in consequence of the vicinity of a greater loadstone. As loadstones possessed of vigorous magnetism are always found only in small pieces, and in pieces of various sizes and force, we must expect every position of their poles. The only thing that we can expect by theory is, that adjoining loadstones will have their friendly poles turned toward each other, and a general prevalence of or tendency to a polarity symmetrical with that of the earth. The reader will find some more observations to this purpose in the article Variation, *Encycl.* p. 623. as also in Gilbert's Treatise, B. III. c. 2. p. 121.

Nor should all strata or masses of iron ore be magnetical. We know that none are susceptible of induced magnetism, but such as are, to a certain degree, in the metallic state. Such ores are not abundant. Nay, even all of such strata do not necessarily acquire magnetism by the action of the great magnet. If their principal dimensions lie nearly perpendicular to the magnetic direction, they will not acquire any sensible quantity. A stratum in this country, rising about 17° to the N. N. W. will scarcely acquire magnetism. It may also happen, that the influence of the great magnet is counteracted by that of some extensive stratum inaccessible to man, by reason of its great depth.

72 Probable cause of their great natural vigour.

Thus we see that all the appearances of the original magnetism of loadstones are perfectly consistent with the notion that they are effects of one general cosmical cause, the action of the great magnet contained in the earth; and that there is no occasion to suppose this great magnet to differ, in its constitution or manner of action, from the small masses of similar matter called loadstone. The only difficulty that presents itself is the great superiority of magnetic force observable in some loadstones over other masses of ores circumjacent, which are not distinguishable by us by any other circumstance. We acknowledge ourselves unable to solve this difficulty; for the magnetism of such pieces is sometimes incomparably stronger than what a bar of iron acquires by position; yet this bar is much more susceptible than the ores which are fit for becoming loadstones. Perhaps there is some chemical change which obtains gradually in certain masses, which aids the impregnation, in the same way that we know that being red hot destroys all magnetism, whether in a metal bar or in an ore. This seems to be confirmed by what we see in some old iron stanchions, which acquire the strongest magnetism in those parts of their substance which are combining themselves with ingredients floating in the atmosphere. That part which is cased in the stone, and exfoliates and splits with rust, being converted into something like what is called finery-cinder, becomes highly and permanently magnetic. Such peculiarities as these, operating for ages, may allow a degree of magnetical impregnation (in whatever this may consist) to take place, to which we can see no resemblance in our experiments. It would be worth while to place iron wires in a tube in the magnetic direction, which could be kept of a proper red heat, while it is converted into æthiops by steam. It is not unlikely that it would acquire a sensible and permanent magnetism in this way. It may be, that the little atoms, as they arrange themselves in a sort of crystalline or symmetrical form, may also arrange so as to favour magnetism. Were this tried in the vicinity of a strong magnet, the effect might be more remarkable and precise. Perhaps, too, while iron is precipitated in a metallic form from its solutions by another metal, something of the same kind may happen. We know that proper ores of iron, exposed to cementation in a low red heat, in the magnetic direction, becomes magnetic.

73 Natural causes of the changes of the magnetic direction.

Notice has been taken in the *Encycl.* article Variation, of the attempts of ingenious men to explain the change which is observed in all parts of the globe, on the direction of the mariner's needle, the gradual change of the variation. The hypothesis of Dr Halley, that the globe which we inhabit is hollow, and incloses a magnetic nucleus, moving round another axis, is not inconsistent with any natural law, if he did not suppose the interval filled up with some fluid. The action of the nucleus and shell on the intervening fluid would gradually bring the two to one common motion of rotation, as may be inferred from the reasonings employed by Newton in his remarks on the Cartesian vortices.

Leaving

Leaving out this circumſtance, there is only another cauſe which can affect, and muſt affect, the rotation of both; namely, the mutual action of the magnetic nucleus, and the maſſes of magnetic matter in the ſhell. If the axis of rotation of this nucleus be different from the line joining its magnetic poles, theſe poles will have a motion relative to the ſhell; and this motion may eaſily be conceived ſuch as will produce the changes of magnetic direction which we obſerve. It may even produce a motion of the northern magnetic pole in one direction, and of the ſouthern pole in the oppoſite direction, and this with the appearance of different periods of rotation, as ſuppoſed by Mr Churchman. We may here obſerve, by the way, that the change of magnetic direction in this country is not nearly ſo great as is commonly imagined. The horizontal needle has ſhifted its poſition about 35° at London ſince 1585; but the point of the dipping needle has not changed 10°. We may alſo obſerve, that when the pole of the central magnet changes its place, the magnetiſm of an extenſive ſtratum, influenced by it, may ſo alter its diſpoſition, as to change the poſition of the compaſs needle in the oppoſite direction to that of the change which the central magnet alone would induce on it.

But as motions have not yet been aſſigned to this nucleus, which quadrate with the obſerved poſitions of the needle, and as the very exiſtence of it is hypothetical, it may not be amiſs to examine whether ſuch a change of variation may not be explained by what we know of the laws of magnetiſm, and of the internal conſtitution of this earth?

1. It is pretty certain that the veins in which loadſtones are found are not parts of the great magnet. This appears from their having two poles while in the mine, and alſo from the very ſmall depth to which man has been able to penetrate. When we compare the poſitions of the dipping needle with thoſe of a ſmall needle near a magnet, we muſt infer, that the poles are very far below the ſurface.

Yet we know that there are magnetiſable ſtrata of very great extent, occupying a very conſiderable portion of the external covering. Though their bulk and abſolute power may be ſmall, when compared with thoſe of the great magnet, yet their greater vicinity to the needles on which obſervations are made, may give them a very ſenſible influence. In this way may a great deal of the obſerved irregularities of the poſitions of the needle be accounted for. In the Lagoon at Teneriffe, *Feuillée* obſerved the variation 13° 30′ weſt in 1724, while at the head of the iſland it was only 5°. The dip at the Lagoon was 63° 30′, greatly ſurpaſſing what was obſerved in the neighbourhood. Muller found, in the mountains of Bohemia, great and deſultory differences of declination, amounting ſometimes to 50°. At Mantua, the variation in 1758 was 12°; while at Bononia and Brixia it was nearly 18°. Great irregularities were obſerved by Goëte in the Gulph of Finland, eſpecially near the iſland of Suſſari, among ſome rocks: on one of theſe, the needle ſhewed no polarity. Captain Cook and Captain Phipps obſerved differences of 10°, extending to a conſiderable diſtance, on the weſt coaſts of North America. In the neighbourhood of the iſland Elba in the Mediterranean, the poſition of the needle is greatly affected by the iron ſtrata, in which that iſland ſo much abounds. In this country, there are alſo obſerved ſmall deviations, which extend over conſiderable tracts of country, indicating a great extent of ſtrata that are weakly magnetic. Since ſuch ſtrata receive their magnetiſm by induction, in a manner ſimilar to a bar of hard ſteel, and ſince we know that this receives it gradually, it may very probably happen, that a long ſeries of years may elapſe before the magnetiſm attains its ultimate diſpoſition.

Here then is a neceſſary change of the magnetic direction; and although it may be very different in different places, according to the diſpoſition and the power of thoſe ſtrata, there muſt be a general vergency of it one way.

2. It is well known that all metals, and particularly iron, are in a progreſs of continual production and demetallization. The veins of metals, and more particularly thoſe of iron, are evidently of poſterior date to that of the rocks in which they are lodged. Chemiſtry teaches us, by the very nature of the ſubſtances which compoſe them, that they are in a ſtate of continual change. This is another cauſe of change in the magnetic direction. Nay, we know that ſome of them have ſuddenly changed their ſituation by earthquakes and volcanoes. Some of the ſtreams of lava from Veſuvius and Ætna abound in iron. This has greatly changed its ſituation; and if the ſtrata from which it proceeded were magnetical, the needle in its neighbourhood muſt be affected. Nay, ſubterranean heat alone will effect a change, by changing the magnetiſm of the ſtrata. Mr Lievog, royal aſtronomer at Breſſeſtedt in Iceland, writes, that the great eruption from Hecla, in 1783, changed the direction of the needle nine degrees in the immediate neighbourhood. This change was produced at a mile's diſtance from the frozen lava; and it diminiſhed to two degrees at the diſtance of 2½ miles. He could not approach any nearer, on account of the heat ſtill remaining in the lava after an interval of 14 months.

All theſe cauſes of change in the direction of the mariner's needle muſt be partial and irregular. But there is another cauſe, which is coſmical and univerſal. Dr Halley's ſuppoſition of four poles, or, at leaſt, the ſuppoſition of irregular and diffuſed poles, ſeems the only thing that will agree with the obſervations of declination. We know that all magnetiſm of this kind (that is, diſpoſed in this manner) has a natural tendency to change. The two northern poles may have the ſame or oppoſite polarities. If they are the ſame, their action on each other tends to diminiſh the general magnetiſm, and to cauſe the centre of effort to approach the centre of the magnet. If they have oppoſite polarities, the contrary effect will be produced. The general magnetiſm of each will increaſe, and the pole (or its centre of effort) will approach to the ſurface. In either of theſe caſes, the compound magnetiſm of the whole may change exceedingly, by a change by no means conſiderable in the magnetiſm of each pair of poles. It is difficult to ſubject this to calculation; but the reader may have very convincing proof of it, by taking a ſtrong and a weaker magnet of the ſame length, and one of them, at leaſt, of ſteel not harder than ſpring temper. Lay them acroſs each other like an acute letter X; and then place a compaſs needle, ſo that its plane of rotation may be perpendicular to the plane of the X. Note exactly the poſition in which the needle ſettles. In a few minutes after, it will be found to change conſiderably,

ſiderably, although no remarkable change has yet happened to the magnets themſelves.

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74 ecula- ns about : origin magne- n. Hy- :heſis of pinus.

We flatter ourſelves, that our readers will grant that the preceding pages contain what may juſtly be called a theory of magnetiſm, in as much as we have been able to conclude every phenomenon in one general fact, the induction of magnetiſm; and have given ſuch a deſcription of that fact and its modifications, that we can accurately predict what will be the appearances of magnets and iron put into any deſired ſituation with reſpect to each other. If our notions of philoſophical diſquiſition (delivered in art. Philosophy, *Encycl. Brit.*) be juſt, we have explained the ſubordinate phenomena, or have given a theory of magnetiſm.

But it is not eaſy to ſatiſfy human curioſity. Men have even inveſtigated, or ſought for cauſes of the perſeverance of matter in its preſent condition. We have not been contented with Newton's theory of the celeſtial motions, and have ſought for the cauſe of that mutual tendency which he called gravitation, and of which all the motions are particular inſtances.

Philoſophers have been no leſs inquiſitive after what may be the cauſe of that mutual attraction of the diſſimilar poles, and the repulſion of the ſimilar poles, and that faculty of mutual impregnation, or excitement, which ſo remarkably diſtinguiſh iron, in its various ſtates, from all other ſubſtances. The action of bodies on each other at a diſtance, has appeared to them an abſurdity, and all have had recourſe to ſome material intermedium. The phenomenon of the arrangement of iron filings is extremely curious, and naturally engages the attention. It is hardly poſſible to look at it without the thought ariſing in the mind of a ſtream iſſuing from one pole of the magnet, moving round it, entering by the other pole, and again iſſuing from the former outlet. Accordingly, this notion has been entertained from the earlieſt times, and different ſpeculatiſts have had different ways of conceiving how this ſtream operated the effects which we obſerve.

The ſimpleſt and moſt obvious was juſt to make it act like any other ſtream of fluid matter, by impulſion. Impulſion is the thing aimed at by all the ſpeculatiſts. They have a notion, that we conceive this way of communicating motion with intuitive clearneſs, and that a thing is fully explained when it can be ſhewn that it is a caſe of impulſion. We have conſidered the authority of theſe explanations in the article Impulsion of this *Supplement*, and need not repeat our reaſons for refuſing it any pre-eminence. But even when we have ſhewn the phenomena to be caſes of impulſion by ſuch a ſtream, the greateſt difficulty, the moſt curious and the moſt embarraſſing, is to aſcertain the ſources of this impulſive motion of the fluid—How, and from what cauſe does it begin? What forces bend it in curves round the magnet? Thoſe philoſophers, whoſe principle obliges them to explain gravitation alſo by impulſe, muſt have another ſtream to impel this into its curves. Acting by impulſion, this magnetic ſtream muſt loſe a quantity of motion equal to what it communicates. What is to reſtore this? What directs it in a particular courſe thro' the magnet? And what is it that can totally alter that courſe—in a moment—in all the phenomena of induced magnetiſm? How does it impel? Lucretius, either of himſelf, or ſpeaking after the Greek philoſophers, makes it impel, not the iron, but the ſurrounding air, ſweeping it out of the way; and thus giving occaſion for the ſurrounding air to ruſh around the magnet, and to hurry the bits of iron toward it. There is, perhaps, more ingenious refinement in this thought than in any of the impulſive theories adopted ſince his day by Des Cartes, Euler, and other great philoſophers: But it is ſagaciouſly remarked by D. Gregory, in his MS. notes on Newton, that this theory of Lucretius falls to the ground; becauſe the experiments ſucceed juſt as well under water as in the air. As to the explanations, or deſcriptions, of the canals and their dock gates, opening in one direction, and ſhutting in the other, conſtructions that are changed in an inſtant in a bar of iron, by changing the poſition of the magnet, we only wonder that men, who have a reputation to loſe, ſhould ever hazard ſuch crude and unmechanical dreams before the public eye. The mind of man cannot conceive the poſſibility of their formation; and if they are really formed, the effects ſhould be the very oppoſite of thoſe that are obſerved: the ſtream ſhould move thoſe bodies leaſt which afford ready channels for its paſſage. If a rag of iron filings be arranged by the impulſion of ſuch a ſtream, it ſhould be carried along by it; and if it is *impelled toward* one end of the magnet, it ſhould be impelled *from* the other end. Since we now know, that each particle of filings is a momentary magnet, we muſt allow a ſimilar ſtream whirling round each. Is that an explanation which exceeds all power of conception?

But has it ever been ſhewn that there is any impulſion at all in theſe phenomena? Where is the impelling ſubſtance? The only argument ever offered for its exiſtence is, that we are reſolved that the phenomena of magnetiſm ſhall be produced by impulſion, and the arrangement of iron filings looks ſomewhat like a ſtream. But enough of this. We truſt that we have ſhewn the way in which this arrangement obtains in the cleareſt manner. Every particle becomes magnetic by induction. This is a fact, which ſets all reaſoning at defiance. The polarity of each rag is ſo diſpoſed, that their adjoining ends turn to each other. This is another uncontrovertible fact. And theſe two facts explain the whole. The arrangement of iron filings, therefore, is a ſecondary fact, depending on principles more general; and therefore cannot, conſiſtently with juſt logic, be aſſumed as the foundation of a theory.

Had magnetiſm exhibited no phenomena beſides the attraction and repulſion of magnets, it is likely that we ſhould not have proceeded very far in our theories, and would have contented ourſelves with reducing theſe phenomena to their moſt general laws. But the communication of magnetiſm ſeems a great myſtery. The ſimple approach of a magnet communicates theſe powers to a piece of iron; and this without any diminution of its own powers. On the contrary, beginning with magnets which have hardly any ſenſible power, we can, by a proper alternation of the manipulations, communicate the ſtrongeſt magnetiſm to as many hard ſteel bars as we pleaſe; and the original magnets ſhall be brought to their higheſt degree of magnetiſm. We have no notion of powers or faculties, but as qualities of ſome ſubſtances in which they are inherent. Yet here is no appearance of ſomething abſtracted from one body, and communicated to, or ſhared with another. The proceſs is like kindling a great fire by a ſimple ſpark; here is is no communication, but only *occasion* given to the exertion of powers inherent in the combustible matter. It appears probable, that the case is the same in magnetism; and that all that is performed in making a magnet is the excitement of powers already in the steel, or the giving occasion for their exertion; as burning the thread which ties together the two ends of a bow, allows it to unbend. This notion did not escape the sagacity of Dr Gilbert; and he is at much pains to shew, that the *coitio magnetica* is a quality inherent in all magnetical bodies, and only requires the proper circumstance for its exertion. He is not very fortunate in his attempts to explain *how* it is developed by the vicinity of a magnet, and how this faculty, or actual exertion of this power, becomes permanent in one body, while in another it requires the constant presence of the magnet.

74 Magnetical hypothesis of Æpinus.

It is to Mr Æpinus, of the Imperial Academy of St Petersburgh, that we are indebted for the first really philosophical attempt to explain all these mysteries. We mentioned, in the article Electricity, *Suppl.* the circumstance which suggested the first hint of this theory to Æpinus, *viz.* the resemblance between the attractions and repulsions of the tourmaline and of a magnet. A material cause of the electric phenomena had long been thought familiar to the philosophers. They had attributed them to a fluid which they called an electric fluid, and which they conceived to be shared among bodies in different proportions, and to be transferable from one to another. Dr Franklin's theory of the Leyden phial, which led him to think that the faculty of producing the electrical phenomena depended on the deficiency as well as the redundancy of this fluid, combined with the phenomena of induced electricity, suggested to Æpinus a very perspicuous method of stating the analogy of the tourmaline and the magnet; which he published in 1758 in a paper read to the academy.

Reflecting more deeply on these things, Mr Æpinus came by degrees to perceive the perfect similarity between all the phenomena of electricity by position and those of magnetism; and this led him to account for them in the same manner. As the phenomena of the Leyden phial, explained in Franklin's manner, shews that a body may appear electrical all over, by having less than its natural quantity of the electric fluid, as well as by having more, it seemed to follow, that it may also be so in respect to different parts of the same body; and therefore a body may become electrified in opposite ways at its two extremities, merely by abstracting the fluid from one end, and condensing it in the other; and thus may be explained the phenomena of induced electricity, where nothing appears to have been communicated from one body to the other. If this be the case, the two ends of a body rendered electric by induction should exhibit the same distinctions of phenomena that are exhibited by bodies wholly redundant and wholly deficient. The redundant ends should repel each other; so should the deficient ends; and a redundant part should attract a deficient. All these results of the conjecture tally exactly with observation, and give a high degree of probability to the conjecture. The similarity of these phenomena to the attractions of the dissimilar poles of a magnet, and the repulsions of the similar poles, is so striking, that the same mode of explanation forces itself on the mind, and led Mr Æpinus to think, that the faculty of producing the magnetical phenomena belonged to a magnetical fluid, residing in all bodies susceptible of magnetism; and that the exertion of this faculty require nothing but the abstraction of the fluid from one end of the magnetic bar, and its constipation in the other. And this conjecture was confirmed by observing, that in the induction of magnetism on a piece of iron, the power of the magnet is not diminished.

All these circumstances led Mr Æpinus to frame the following hypothesis:

1. There exists a substance in all magnetic bodies, which may be called the magnetic fluid; the particles of which repel each other with a force decreasing as the distance increases.

2. The particles of magnetic fluid attract, and are attracted by the particles of iron, with a force that varies according to the same law.

3. The particles of iron repel each other according to the same law.

4. The magnetic fluid moves, without any considerable obstruction, through the pores of iron and soft steel; but is more and more obstructed in its motion as the steel is tempered harder; and in hard tempered steel, and in the ores of iron, it is moved with the greatest difficulty.

In consequence of this supposed attraction for iron, the fluid may be contained in it in a certain determinate quantity. This quantity will be such, that the accumulated attraction of a particle for all the iron balances, or is equal to, the repulsion of all the fluid which the iron contains. The quantity of fluid competent to a particle of iron is supposed to be such, that the repulsion exerted between it and the fluid competent to another particle of iron is also equal to its attraction for that particle of iron: And therefore the attraction between the fluid in an iron bar A for the iron of another bar B, is just equal to its repulsion for the fluid in B; it is also equal to the repulsion of the iron in A for the iron in B. This quantity of fluid residing in the iron may be called its natural quantity.

In consequence of the mobility through the pores of the iron, the magnetic fluid may be abstracted from one end of a bar, and condensed in the other, by the agency of a proper external force. But this is a violent state. The mutual repulsion of the particles of condensed fluid, and the attraction of the iron which it has quitted, tend to produce a more uniform distribution. If we reflect on the law of action, we shall clearly perceive, that somewhat of this tendency must obtain in every state of condensation and rarefaction, and that there can be a perfect equilibrium only when the fluid is diffused with perfect uniformity. This, therefore, may be called the natural state of the iron.

If the resistance opposed by the iron to the motion of the magnetic fluid be like that of perfect fluids to the motion of solid bodies, arising entirely from the communication of motion, there is no tendency to uniform diffusion so weak as not to overcome such resistance, and finally to produce this uniform distribution. But (as is more probable) if the obstruction resembles that of a clammy fluid, or of a soft plastic body like clay, some of the accumulation, produced by the agency of an external force, may remain when the force is removed; the diffusion will cease whenever the equalising force is just in equilibrio with the obstruction.

All the preceding circumstances of the hypothesis are

are ſo perfectly analogous to the hypotheſis of Mr Æpinus for explaining the electrical phenomena, which is given in detail in the article Electricity of this *Supplement*, that it would be ſuperfluous to enter into a minute diſcuſſion of their immediate reſults. We therefore beg the reader to peruſe that part of the article Electricity where the elements of Æpinus's hypotheſis are delivered, and the phenomena of induced electricity explained (viz. from no 11. to 60. incluſive), and to ſuppoſe the diſcourſe to relate to the *magnetical* fluid. Let N, S, *n*, *s*, be conſidered as the overcharged and undercharged parts of a magnetical body, or the poles of a magnet, and of iron rendered magnetical by induction. We ſhall confine our obſervations in this place to thoſe circumſtances in which the mechanical phenomena of magnetiſm are limited by the circumſtance that magnets always contain their natural quantity of fluid; ſo that their action on iron, and on each other, depends entirely on its unequable diſtribution; as is the caſe with induced electricity.

75 Magnetiſm how induced on iron by juxtaposition.

Let the magnet NAS (fig. 26.), having its north pole NA overcharged, be ſet near to the bar *n* B *s* of common iron, and let their axes form one ſtraight line. Then (as in the caſe of electrics) the overcharged pole NA acts on the bar B only by means of the redundant fluid which it contains. For that portion of its fluid, which is juſt ſufficient for ſaturating the iron, will repel the fluid in B, juſt as much as the iron in NA attracts it; and therefore the fluid in B ſuſtains no change from this portion of the fluid in NA. In like manner, the pole SA acts on B only in conſequence of the iron in SA, which is not ſaturated or attended by its equivalent fluid.

If the fluid in B is immoveable, even the redundant fluid in NA, and redundant iron in SA, will produce no *ſenſible* effect on it: For every particle of iron in B is accompanied by as much fluid as will balance, by its repulſions and attractions, the attractions and repulſions of the equidiſtant particle of iron. But as the magnetical fluid in B is ſuppoſed to be eaſily moveable, it will be repelled by the redundant fluid in AN toward the remote extremity *n*, till the reſiſtance that it meets with, joined to its own tendency to uniform diffuſion, juſt balances the repulſion of AN. This tendency to uniform diffuſion obtains as ſoon as any fluid quits its place; as has been ſufficiently explained in the Supplementary article Electricity, no 16, 17, &c.

But, at the ſame time, the redundant iron in AS attracts the fluid in B, and would abſtract it from B *n*, and condenſe it into B *s*. This attraction oppoſes the repulſion now mentioned. But, becauſe AS is more remote from every point of B than AN is from the ſame point, the repulſions of the redundant fluid in AN will prevail; and, on the whole, fluid will be propelled toward *n*, and will be rarefied on the part B *s*. But as to what will be the law of diſtribution, both in the redundant and deficient parts of B, it is plain that nothing can be ſaid with preciſion. This muſt depend on the diſtribution of the fluid in the magnet NAS. The more diffuſed that we ſuppoſe the redundant fluid and matter in the magnet, the farther removed will the centres of effort of its poles be from their extremities; the ſmaller will be the action of AN and AS, the ſmaller will be their difference of action; and therefore the ſmaller will be the condenſation in B *n*, and the rarefaction in B *s*. Hence we learn, in the outſet of this attempt to explanation, that the action of a magnet will be ſo much the greater as its poles are more concentrated. This is agreeable to obſervation, and gives ſome credit to the hypotheſis. We can juſt ſee, in a very general manner, that the fluid will be rarer than its natural ſtate in *s*, and denſer in *n*; and that the change of denſity is gradual, and that the denſity may be repreſented by the ordinates of ſome line *c b d* (fig. 27.), while the natural denſity is repreſented by the ordinates to the line C *b* D, parallel to *s n*. There will be ſome point B of the iron bar, where the fluid will be of its natural denſity, and the ordinate B *b* will meet the line *c b d* in the point of its interſection with CD.

All this action is internal and imperceptible. Let us inquire what will be the *ſenſible* external action. There is a ſuperiority of attraction towards the magnet: For ſince the magnetic action is ſuppoſed to diminiſh continually by an increaſe of diſtance, the curve, whoſe ordinates repreſent the forces, has its convexity toward the axis. Alſo, the force of the poles AN, AS, are equal at equal diſtances: For, by the hypotheſis the attraction and repulſion of an individual particle are equal at equal diſtances; and the condenſation in AN is equal to the deficiency in AS, by the ſame hypotheſis; becauſe NAS ſtill contains its natural quantity of fluid. Therefore the action of both poles may be expreſſed by the ordinates of the ſame curve, and they will differ only by reaſon of their diſtances. We may therefore expreſs the actions by the four ordinates M *m*, P *p*, N *n*, Q *q*, of fig. 2.; of which the property (deduced from the ſingle circumſtance of its being convex toward the axis) is, that M *m* + Q *q* is greater than P *p* + N *n*. There is therefore a ſurplus of attraction. It is only this ſurplus that is perceived. The fluid, moveable in B, but retained by it ſo as not to be allowed to eſcape, is preſſed towards its remote end *n* by the exceſs P *p* — Q *q* of the repulſion of the redundant fluid in AN, above the attraction of the redundant iron in AS. This exceſs on every particle of the fluid is tranſmitted, by the common laws of hydroſtatics, to the ſtratum immediately incumbent on the extremity *n*, and B is thus preſſed away from A. But every particle of the ſolid matter in B is attracted towards A by the exceſs M *m* — N *n* of the attraction of the redundant fluid in AN above the repulſion of the redundant iron in AS: and this exceſs is greater than the other; for $\overline{m+q}$ is greater than $\overline{p+n}$.

The piece of common iron *n* B *s* is therefore attracted, *in conſequence* of the fluid in it having been propelled towards its remote extremity, and diſtributed in a manner ſomewhat reſembling its diſtribution in NAS. Now, in this hypotheſis, magnetiſm is held to depend entirely on the diſtribution of the fluid. B has therefore become a magnet, has magnetiſm induced on it, and, only in conſequence of this induction, is attracted by A.

Had we ſuppoſed the deficient, or ſouth pole of A, to have been neareſt to B, the redundant matter in AN would have attracted the moveable fluid in B more than the remoter redundant fluid in AS repels it; and, on this account, the magnetic fluid would have been conſtipated in B *s*, and rarefied in B *n*. It would, in this caſe alſo, have been diſtributed in a manner ſimilar to its

its ſituation in the magnet. And B would therefore have been a momentary magnet, having its redundant pole fronting the deficient or diſſimilar pole of A. It is plain that there would be the ſame ſurplus of attraction in this as in the former inſtance, and B would (on the whole) be attracted in conſequence, and only in conſequence, of having had a properly diſpoſed magnetiſm induced on it by juxtapoſition. The ſenſible attraction, in this caſe, is a *conſequence* of the diſtribution now deſcribed; becauſe, ſince the fluid conſtipated in the end next to A cannot quit B, the tendency of this fluid toward A muſt preſs the ſolid matter of B in this direction (by hydroſtatical laws) more than this ſolid matter is repelled in the oppoſite direction.

Thus it appears that the hypotheſis tallies preciſely with the induction of magnetiſm, We do not call this an explanation of the phenomenon; for the fact is, that it is the hypotheſis that is explained by the phenomenon: That is, if any perſon be told that induced magnetiſm is produced by the action of a fluid, in conſequence of its ſituation being changed, he will find, that in order to agree with the attraction of diſſimilar, and the repulſion of ſimilar poles, he muſt accommodate the fluid to the phenomena, by giving it the properties aſſigned to it by Æpinus.

76 Conformity of the hypotheſis with a vaſt variety of phenomena.

But the agreement with this ſimpleſt poſſible caſe of the moſt ſimple example of induced magnetiſm, is not enough to make us adopt the hypotheſis as adequate to the explanation of all the magnetic phenomena. We muſt confront the hypotheſis with a variety of obſervations, to ſee whether the coincidence will be without exception.

When the key CB, in fig. 8. is brought below the conſtipated north pole N of the magnet SAN, its own moveable fluid is propelled from C towards B, and is diſpoſed in CB nearly after the ſame manner as in SAN. Therefore the redundant fluid in the lower end of the key repels the moveable fluid in the wire BD more than the redundant matter in the upper end C attracts it; and thus the fluid is rarefied in the upper end of the wire BD, and condenſed in its lower end D. CB and BD therefore are two temporary magnets, having their diſſimilar poles in contact, or neareſt to each other. This is all that is required for their attraction. This effect is promoted by the action of N on the wire BD, alſo propelling the fluid toward D; and thus increaſing the mutual attraction of CB and BD. In like manner, when the key CB is held above the magnet, the moveable fluid in it is more attracted by the redundant matter in SA than it is repelled by the more remote redundant fluid in AN. The ſame thing happens to the fluid in the wire BD. Therefore CB and BD muſt attract each other; and the key will carry the wire, although the magnet is below it, and alſo attracts it. This ſingularity proceeds from the almoſt perfect mobility of the fluid in the two pieces of common iron, which renders their poles extremely conſtipated; whereas the hardneſs required for the fixed magnetiſm of the magnet prevents this complete conſtipation and rarefaction. This can be ſtrictly demonſtrated in the caſe of ſlender rods of iron; but we can ſhew, and experience confirms it, that in other caſes, depending on the ſhape and the temper of the pieces, the wire will not adhere to the key, but to the magnet.

In the various ſituations and poſitions of the key and wire repreſented in fig. 7. the actions of ſome of the poles on the moveable fluid in the iron are oblique in regard to the length of the pieces; but, ſince the moveable matter is ſuppoſed to be a fluid, it will ſtill be propelled along the pieces, notwithſtanding their obliquity, in the ſame manner as gravity makes water occupy the lower end of a pipe lying obliquely. If indeed the magnetic fluid could eſcape from the iron without any obſtruction by the propulſion of the magnet, it could produce no attraction, or ſenſible motion, any more than light does in a tranſparent body. What is demonſtrated of the electric fluid in the Supplemental article Electricity, n° 133. is equally true here. Why the fluid does not eſcape when it is ſo perfectly moveable, is a queſtion of another kind, and will be conſidered afterwards; at preſent, the *hypotheſis* is, that it does not eſcape.

If the key and wire have the poſition fig. 10. n° 1. the fluid is expelled from the parts in contact, and is condenſed in the remote ends. So far from attracting each other, the key and wire muſt repel. They are temporary magnets, having their ſimilar poles fronting each other. They muſt repel each other, if preſented in a ſimilar manner to the ſouth pole of the magnet.

If they be preſented as in n° 2. fig. 10. where the actions of both poles of the magnet are equal, the ſtate of the fluid in them will not be affected. The redundant pole of the magnet repels the moveable fluid in both the key and the wire toward the upper ends; but the deficient pole acts equally on it in the oppoſite direction. It therefore remains uniformly diſtributed through their ſubſtance; and therefore they can exhibit no appearance of magnetiſm.

But if the key and wire be preſented to the *ſame* part of the magnet, but in another poſition, as ſhewn in fig. 8. n° 3. the fluid of the key will be abſtracted from C, and condenſed in B, by the joint action of both poles of the magnet. The ſame thing will happen in the wire BD. Here, therefore, we have two magnets with their diſſimilar poles touching. They will attract each other ſtrongly; and if carried gradually toward the upper or lower end of the magnet, they will ſeparate before the point B arrives abreaſt of N or S. For ſimilar reaſons, the pieces of iron preſented to the middle of the magnet, as in fig. 10. will have one ſide a weak north pole, and the other ſide a weak ſouth pole; but this will not be conſpicuous, unleſs the pieces be broad.

This experiment ſhews, in a very perſpicuous manner, the competency of the hypotheſis to the explanation of the phenomena. When the fluid is not moved, magnetiſm is not induced, even on the moſt ſuſceptible ſubſtance.

When a piece of iron A (fig. 10.), nearly as large as the magnet can carry, hangs at either pole, a large piece of iron B, brought near to the pole on the other ſide, ſhould cauſe it immediately to fall. If S be the deficient pole, it cauſes the fluid in A to aſcend to the top, and A is attracted: but, for the ſame reaſon, it cauſes the fluid in B to accumulate in its lower end. This redundant fluid muſt evidently counteract the redundant matter in S, in the induction of the magnetic ſtate on A. Being more remote from A than S is, it cannot wholly prevent the accumulation in the upper end of A; but it renders it ſo trifling, that the remaining attraction

attraction thence arising cannot support the weight of A. This is a very instructive experiment.

But if, on the contrary, we bring a large piece of iron C below the heavy key A, this piece C will have its fluid accumulated in its upper end, both by the action of A on it, and by the action of the magnet. The attraction of the magnet for A should therefore be augmented; and a magnet should carry a heavier lump of iron when a great lump is beyond it. And it is clear (we think), for similar reasons, that the magnetism of the magnet itself in fig. 11. should be increased by bringing a great lump of iron near its opposite pole: for the magnet differs from common iron only in the *degree* of the mobility of its fluid.

When a compass needle is placed opposite to the redundant pole N of a magnet AN (fig. 28.), it arranges itself magnetically. If a piece of common iron be now presented laterally to the near point of the needle, the redundant matter in the adjoining parts of the needle and the iron should make them repel; but if presented to the remote end, the redundant matter in the iron should attract the redundant fluid in that end of the needle, and that end should turn toward the iron.

A parcel of slender iron wires, carried by the pole of a magnet, as in fig. 29. should avoid each other. If N be the redundant pole, the fluid in each wire will be driven to the remote end, where it must repel the similarly situated fluid of its neighbour. The same external appearance must be exhibited by pieces of wire hanging at the deficient pole of the magnet.

The redundant pole of a magnet A (fig. 30.) being held vertically above the centre of two pieces of common iron, moveable round a slender pin, renders the middle of each deficient, and their extremities redundant; therefore they should repel each other, and spread out. The same effect should be produced by the undercharged pole of A.

The redundant pole of a magnet A being applied to one branch of the piece of forked iron NCS (fig. 31.), should drive the fluid into its remote parts C, and then the branch NC should be able to induce the magnetic state on a bit of iron D. But if the deficient pole S of another magnet B be applied to the other branch, these two actions should counteract each other at C, and the iron should remain indifferent, and fall.—Yet the magnet B alone would equally cause C to carry the piece of iron.

It is surely unnecessary to demonstrate, that the consequence of this hypothesis must be, that when a magnet puts any piece of iron into the magnetic state, its own magnetism is improved. For the induced magnetism of the iron is always so disposed as to give the fluid in the magnet a greater constipation where already condensed, and to abstract more fluid from the parts already deficient. If magnetism be produced by such a fluid, a magnet must always improve by lying any how among pieces of iron.

But the case may be very different when magnets are kept in each others neighbourhood. When the overcharged poles of two magnets are placed fronting each other, the redundant fluid in each repels that in the other more than it attracts the remoter redundant iron. The magnets must therefore repel each other. Moreover, in rendering them magnetical, the repulsion of redundant fluid, or the attraction of redundant matter of some other magnet, had been employed; and when the magnet was removed, some of the constipated fluid overcame the obstruction to its uniform diffusion, and escaped into the deficient pole; what remains is withheld by the obstruction, and the restoring forces are just in equilibrio with this obstruction. If we now add to them the repulsion of redundant fluid, directed toward the deficient pole, some more of the constipated fluid must be driven that way, and the magnet must be weakened. Nay, it may be destroyed, and even reversed, if one of the magnets be very powerful, and have its own magnetism very fixed; that is, if its fluid be very redundant, and meet with very great obstruction to its motion. Hence it also should follow, that the repulsion observed between two magnets should be weaker at the same distance than their attraction, and should follow a different law. For in the course of the experiments, the situation of the fluid in the magnets is continually changing, and approaching to a state of uniform diffusion.

77 Explanation of the directive power, and of polarity.

Let us now examine into the sensible effect of this fluid on a magnet which cannot move from its place, but can turn on its centre like a compass needle. This scarcely requires any discussion. We should only be repeating with regard to the redundant fluid and redundant matter, what we formerly said in regard of north pole and south pole; the little magnet must arrange itself nearly in the tangent of a magnetic curve. But it requires a more minute investigation to determine what the sensible phenomenon should be when the fluid of the little magnet is perfectly moveable.

Suppose therefore a particle C (fig. 32.) of magnetic fluid, at perfect liberty to move in every direction, and acted on by the redundant and deficient poles of a magnet NAS. The redundant iron in S attracts C in the direction and with the force CF, while the redundant fluid in N repels it in the direction and with the force CD. By their joint action it must be urged in the direction and with the force CE, the diagonal of the parallelogram CDEF, which must be accurately a tangent to a magnetic curve. If this particle of fluid belong to the piece of iron n C s, which lies in that very direction, it will unquestionably be pushed towards the extremity n. The same must happen to other particles. Hence it appears that a piece of common iron in this situation and position must become a magnet, and must retain this position; only the mechanical energy of the lever may change the equilibrium of the magnetic forces a little; because when the piece of iron n C s has any sensible magnitude, the action on its different points will be a little unequal, and may compose diagonals which divide a little from the tangent.

Should the iron needle chance not to have the exact position, but not deviate very far from it, it is also clear that the fluid, not being able to escape, will press on the side toward which it is impelled; and thus will cause the needle to turn on its pivot, and finally arrange itself in magnetical and mechanical equilibrium, deviating so much the less from a tangent to a magnetic curve as the piece of iron is smaller. Any piece of common iron, held in the neighbourhood of a magnet, will become more overcharged at one end and undercharged at the other, in proportion as the position of its length comes nearer to the tangent of a magnetic curve. A slender wire held perpendicular to this position, that is, is, perpendicular to the curve, ſhould not acquire any ſenſible magnetiſm, either attractive or directive.

78 Explanation of the curves formed by iron filings.

We ſurely need not now employ many words to ſhew that a parcel of iron filings, ſtrewed round a magnet, ſhould arrange themſelves in the primary magnetic curves, or that when ſtrewed round two magnets they ſhould form the ſecondary or compoſite curves.

79 Explanation of tranſitory and of permanent magnetiſm, and of indifferent and determinate magnetiſm.

Let us now enquire more particularly into the modifications of this accumulation of magnetic fluid which may reſult from the nature of the piece of iron, as it is put into the magnetic ſtate. The propelling force of A acts againſt the mutual repulſion of the particles of fluid in B, and alſo againſt the obſtruction to its motion through the pores of B. The greater this obſtruction, the ſmaller will be the accumulation which ſuffices, in conjunction with the obſtruction and the attraction of the deſerted iron, to balance the propulſive force of the redundant fluid in the overcharged pole of A. This circumſtance therefore muſt limit the accumulation that can be produced in a given time. Therefore the magnetiſm produced on ſoft ſteel or iron ſhould be greater than that produced in hard ſteel at the ſame diſtance. Hence the great advantage of ſoft poles, or of armour, or of capping, to a loadſtone, or to a bundle of hard bars. The beſt form and dimenſions of this armour is certainly determinable by mathematical principles, if we knew the law of magnetical action, and the diſpoſition of the magnetiſm in our loadſtone; but theſe are too imperfectly known in all caſes for us to pretend to give any exact rules. We muſt decide experimentally by making the caps large at firſt, and reducing them till we find the loadſtone carry leſs; then make them a ſmall matter larger. The chief things to be minded are the purity, the uniformity, and the ſoftneſs of the iron, and the cloſeſt poſſible contact.

If the obſtruction reſemble that to motion through a clammy fluid, the final accumulation in hard ſteel may be nearly equal to that in iron, but will require much longer time. Alſo, becauſe ſuch obſtruction to the motion of the fluid will nearly balance the propelling force in parts that are far removed from the magnet, the accumulation will begin thereabouts, while the bar beyond is not yet affected. A redundant pole will be formed in that place. This will operate on what is *immediately* beyond it, driving the fluid farther on, and occaſioning another accumulation at a ſmall diſtance. This may produce a ſimilar effect in a ſtill ſmaller degree farther on. Thus the ſteel bar will have the fluid alternately condenſed and rarefied, and contain alternate north and ſouth poles. This ſtate of diſtribution will not be permanent; fluid will be gradually changing its place; theſe poles will gradually advance along the bar, the remoter poles becoming gradually more diffuſe and faint; and it will not be till after a very long time that a regular magnetiſm with two poles will be produced. To ſtate mathematically the procedure of this mechaniſm would require many pages. Yet it may be done in ſome ſimple caſes, as Newton has ſtated the proceſs of aerial undulation. But we cannot enter upon the taſk in this limited diſſertation. What is ſaid in the Supplementary article Electricity (n° 217, 218.) on the diſtribution of the electric fluid in an imperfect inſulator, will aſſiſt the reader to form a notion of the ſtate of magnetiſm during its induction. That ſuch alternations proceed from ſuch mechaniſm, we have ſufficient proof in the inſtances mentioned in the former part of this article. The wave, or curl, produced on the ſurface of a clammy fluid, is a phenomenon of the ſame kind, and owing to ſimilar cauſes.

When the magnet which has produced all theſe changes is removed, it is evident that a part of this accumulation will be undone again. The repulſion of the condenſed fluid, and the attraction of the deſerted iron, will bring back ſome of the fluid. But it is very evident, that a part of the accumulation will remain, by reaſon of the obſtruction to its motion in returning; and this remainder muſt be ſo much the greater as the obſtruction to the change of ſituation is greater. In ſhort, we cannot doubt but that the magnetiſm which remains will be greater in hard than in ſpring-tempered ſteel.

80 Rationale of the proceſs for making magnets.

Thus have we traced the hypotheſis in a great variety of circumſtances and ſituations, and pointed out what ſhould be the external appearance in each. We did not, in each inſtance, mention the perfect coincidence of theſe conſequences with what is really obſerved, but left it to the recollection of the reader. The coincidence is indeed ſo complete, that it ſeems hardly poſſible to refuſe granting that nature operates in this or ſome very ſimilar manner. We get ſome confidence in the conjecture, and may even proceed to explain complicated phenomena by this hypothetical theory. We might proceed to ſhew, that the effects of all the methods practiſed by the artiſts in making artificial magnets are eaſy conſequences of the hypotheſis; but this is hardly neceſſary. We ſhall juſt mention ſome facts in thoſe proceſſes which have puzzled the naturaliſts.

1. A ſtrong magnet is known to communicate the greateſt magnetiſm to a bar of hard ſteel; but Muſchenbroek frequently found, that a weak magnet would communicate more to a ſoft than to a hard bar.

Explanation. When the magnet is ſtrong enough to impregnate both as highly as they are capable of, the hard bar muſt be the ſtrongeſt; but if it can ſaturate neither, the ſpring-tempered bar muſt be left the moſt magnetical.

2. A ſtrong magnet has ſometimes communicated no higher magnetiſm than a weaker one; both have been able to ſaturate the bar.

3. A weak magnet has often impaired a ſtrong one by ſimply paſſing along it two or three times; but a piece of iron always improves a magnet by the ſame treatment.

Explanation. When the north pole of a weak but hard magnet is ſet on the north pole of a ſtrong one, it muſt certainly repel part of the fluid towards the other end, and thus it muſt weaken the magnet. When it is carried forward, it cannot repel this back again, becauſe it is not of itſelf ſuppoſed capable of making the magnet ſo ſtrong. But the end of a piece of iron, always acquiring a magnetiſm oppoſite to that of the part which it touches, muſt increaſe the accumulation of fluid where it is already condenſed, and muſt expel more from thoſe parts which are already deficient.

4. All the parts of the proceſs of the double touch, as practiſed by Meſſrs Mitchell and Canton, are eaſily explained by this hypotheſis. A particle of fluid p (fig. 33.), ſituated in the middle between the two magnets, is repelled in the direction $p\ e$ by the redundant pole of the magnet AN, whoſe centre of effort is ſuppoſed to be

be at C. It is attracted with an equal force in the direction pd toward the centre of effort of the deficient pole of AS. By these combined actions it is impelled in the direction pf. Now it is plain that, although by increasing the distance between N and S, the forces with which these poles act on p are diminished, yet the compound force pf may increase by the diminution of the angle dpe. If the action is as $\frac{1}{x^2}$, pf will be greatest when $\frac{\text{Cos.}\, dpf}{dp^2}$ is a maximum, or (nearly) when $\text{Sin.}^2\, dpf \times \text{Cos.}\, dpf$ is a maximum: but this depends on the place of the centre of effort. We can, however, gather from this observation, that the nearer we suppose the centres of effort of the poles N and S to the extremities of the magnets, the nearer must they be placed to each other. But we must also attend to another circumstance; that by bringing the poles nearer together, although we produce a greater action on the intervening fluid, this action is exerted on a smaller quantity of it, and therefore a less effect may be produced. This makes a wider position preferable; but we have too imperfect a knowledge of the circumstances to be able to determine this with accuracy. The unfavourable action on the fluid beyond the magnets must also be considered. Yet all this may be ascertained with precision in some very simple instances, and the determination might be of service, if we had not a better method, independent of all hypotheses or theory; namely, to place the magnets at the distance where they are *observed* to lift the heaviest bar of iron; then we are certain that their action is most favourable, all circumstances being combined.

We also see a sufficient reason for preferring the position of the magnets employed by Mr Antheaume (and before him by Mr Servington Savery), in his process for making artificial magnets. The form of the parallelogram $dp'ef$ is then much more favourable, the diagonal pf being much longer.

We also see, in general, that, by the method of double touch, a much greater accumulation of fluid may be produced than by any other known process.

And, lastly, since no appearances indicate any difference between natural and artificial magnetism, this hypothesis is equally applicable to the explanation of the phenomena of natural magnetism; such as the position of the horizontal, and of the dipping needle, and the impregnation of natural loadstones.

Having such a body of evidence for the aptitude of this hypothesis for the explanation of phenomena, it will surely be agreeable to meet with any circumstances which render the hypothesis itself more probable. These are not wanting; although it must be acknowledged that nothing has yet appeared, besides the phenomena of magnetism, to give us any indication of the existence of such a fluid; but there are many particulars in their appearance which greatly resemble the mechanical properties of a fluid.

81
obabili- of the stence a mag- ical d.

Heating a rod of iron, and allowing it to cool in a position perpendicular to the magnetic direction, destroys its magnetism. Iron is expanded by heat. If the particles of the magnetic fluid are retained between those of the iron, notwithstanding the forces which tend to diffuse them uniformly, they may thus escape from between the ferruginous particles which withheld them. For similar reasons, magnetism should be acquired by heating a bar and letting it cool in the magnetic direction. But, besides this evident mechanical *opportunity* of motion, the union of fire (or whatever name the neologists may choose to give to the cause of expansion and of heat) with the particles of iron may totally change the action of those particles on the particles of fluid in immediate contact with them; nay, it may even change the sensible law of action between magnet and magnet. Of this no one can doubt who understands the application of mathematical science to corpuscular attraction (See Boscovich, *Suppl.*) A change may be produced in the action between magnets without any remarkable change happening in the actions within the magnet, and it may be just the reverse. The union of fire with the magnetic fluid may increase the mutual repulsion of its parts, as it does in all aerial fluids or gases. This alone would produce a dissipation of some magnetism. It may increase the attraction (at insensible distances) between the fluid and the iron, as it does in numberless cases in chemistry.

82
Farther grounds of belief.

It is well known that violently knocking or hammering a magnet weakens its force, and that hammering a piece of iron in the magnetic direction will give it some magnetism. By this treatment the parts of the iron are put into a tremulous motion, alternately approaching and receding from each other. In the instants of their recess, the pent-up particles of the fluid may make their escape. A quantity of small shot may be uniformly mixed with a quantity of wheat, and will remain so for ever, if nothing disturb the vessel; but continue to tap it smartly with a stick for a long time, and the grains of small shot will escape from their confinements, and will all go to the bottom. We may conceive the particles of magnetic fluid to be affected in the same way. The same effect is produced by grinding or filing magnets and loadstones. The latter are frequently made worthless by grinding them into the proper shape. This should be avoided as much as possible, and it should always be done in moulds made of soft iron and very massive; but this will not always prevent the dissipation of *strong* magnetism. As a farther reason for assigning this cause for the dissipation in such cases, it must be observed (Muschenbroek takes notice of it), that a magnet or loadstone may be ground at its neutral point without much damage. But we had the following most distinct example of the process. A very fine artificial magnet was suspended by a thread, with its south pole down. A person was employed to knock it incessantly with a piece of pebble, in such a manner as to make it ring very clearly, being extremely hard and elastic. Its magnetism was examined from time to time with a very small compass needle. In three quarters of an hour, its magnetism was not only destroyed, but the lower end shewed signs of a north pole. The same magnet was again touched, and made as strong as before, and was then wound about very tight with wetted whipcord, leaving a small part bare in the middle. It was again knocked with the pebble, but could no longer ring. At the end of three quarters of an hour its magnetism was still vigorous, and was not near gone after two hours and a quarter. We discharged a Leyden jar (coated with gold leaf) in the same way. It stood on the top of an axis; and while this was turned round, the edge was rubbed with a very dry cork filled with

with rosin, and fastened to the end of a glass rod. This made the jar sound like the glass of a harmonica. One of them was split in this operation.

A small bar of steel was heated red hot and tempered hard between two strong magnets lying in shallow boxes filled with water, and was more strongly impregnated in this way than in any other that we could think of for a bar of that shape. It has not yet been ascertained in what temperature it is most susceptible of magnetism, but it was considerably hotter than to be just visible in a dark place. It is no objection to our way of conceiving magnetism, that the fluid is immoveable or inactive when the iron is red hot. Either of these, or both of them, may result from the union with the cause of heat. Even a particular degree of expansion may so change the law of action as to make it *immoveable*; or the union with caloric may render it *inactive* at all sensible distances. We cannot but think that some very instructive facts might be obtained by experiments made on iron in the moment of its production, and changes in various chemical processes. All magnetism is gone when it is united with sulphur and arsenic in the greatest number of ores; and when it is in the state of an ochre, rust, æthiops, or solution in acids; and when united with astringent substances, such as galls. When, and in what state, does it become magnetic? And whence comes the fluid of Æpinus? It were worth while to try whether magnets have any influence in the formation or crystallization of the martial salts; and what will be their effect on iron when precipitated from its solutions by another metal, &c. &c.

83 Why magnets have always more than one pole.

There remains one remarkable fact to be taken notice of, which, in one point of view, is a confirmation of the hypothesis, but in another presents considerable difficulties. It is well known that no magnet has ever been seen which has but one pole; that is, on the hypothesis of Æpinus, which is wholly redundant, or wholly deficient. If all magnetism be either the immediate or the remote effect of the great magnet contained in the earth, and if it be produced by induction, without any communication of substance, but only by changing the disposition of the fluid already in the iron, we never should see a magnet with only one pole. It must be owned, that we never can make such a magnet by any of the processes hitherto described; but the existence of such does not seem impossible. Supposing a magnet, of the most regular magnetism, having only two poles; and that we cut it through at the neutral point, or that we cut or break off any part of it—the fact is (for the experiment has been tried ever since men began to speculate about magnetism), that each part becomes an ordinary magnet, with two poles, one of which is of the same kind as before the separation. The question now is, What should happen according to the theory maintained by Æpinus?—*Tentam. Theor. Elect. et Magnetismi*, p. 104, &c.

Let NAS (fig. 34.) be a magnet, of which N is the overcharged pole. Let the ordinates of the curve DAE express the difference between the natural density of the fluid, in a state of uniform diffusion, and its density as it is really disposed in the magnet. The area $p\,n$ND will there express the quantity of redundant fluid in the part n N, and the area q ES m expresses the fluid wanting in the part S m. The intersection A marks that part of the magnet where the fluid is of its natural density. Suppose the part N n to be separated from the rest, containing the redundant fluid ND$p\,n$. The tendency of this fluid to escape from the iron with which it is connected will be greater (Mr Æpinus thinks) than before; because its tendency to quit the magnet formerly was repressed by the attractions of the redundant matter contained in AS. This is certainly true of the extremity N; nay, perhaps of all the old external surface. Fluid will therefore escape. Suppose that so much has quitted the iron that the point n has the fluid of its natural density, as is represented in n° 3. there is still a force operating at n, tending to escape, arising from the repulsion of all the redundant fluid n DN. If this be sufficient for overcoming the obstruction, it will really escape, and the iron will be left in the state represented by n° 4. with an overcharged part f N, and an undercharged part $f\,n$.

In like manner, the tendency of the magnetic fluid surrounding the magnet to enter into its deficient pole, will be greater when it is separated from the other, not being checked by the repulsion of the redundant fluid in that other.

Mr Æpinus relates some experiments which he made on this subject. The general result of them was, that the moment the parts were separated, each had two poles, and that the neutral point of each magnet was much nearer to the place of their former union than to their other ends. In a quarter of an hour afterward, the neutral points had advanced nearer to their middle, and continued to do so, by very small steps, for some hours, and sometimes days, and finally were stationary in their middles.

84 Defects of this reasoning.

We acknowledge that this reasoning does not altogether satisfy us, and that the gradual progress of the neutral point toward the middle of each piece, although agreeable to what should result from an escape of fluid, is not a proof of it. We know already, that the induction of magnetism is a progressive thing; and we should have expected this change of the situation of the neutral point, whatever be the nature of magnetism. There is something similar to this, and perhaps equally puzzling, in the immediate recovery of magnetism which has been weakened by heat; it is partly recovered on cooling.

But our chief difficulty is this: At the point A (fig. 34.) every thing is in equilibrium before the fracture. The particle A is repelled by the redundant fluid in AN, and attracted by the redundant matter in AS; yet it does not move, for the magnetism is supposed to have permanency. Therefore the obstruction at A cannot be overcome by the united repulsion of AN and attraction of AS. Nor can the obstruction at N be overcome by the difference of these two forces. Now suppose AS annihilated. The change made on the state of things at A is surely greater than that at N, because the force abstracted is greater, the distance being less. It does not clearly appear, therefore, that the removal of AS should occasion an efflux at N. This, however, is not impossible; because the fluid may be so disposed, by great constipation near N, and no great excess of density near A, that a smaller change at N may produce an efflux there. But surely the tendency to escape at A must now be diminished, instead of being greater after the fracture. And if any escape from N, this will still more diminish that tendency to escape from

from A. It does not therefore appear a clear consequence of the general theory, that the constipated fluid should escape; and more particularly, that A should become deficient. And with respect to the entry of fluid into the other fragment, and its becoming overcharged at *m*, the reasoning seems still less convincing. The steps of the physical process in the two parts of the original magnet are by no means convertible or counterparts of each other. There is nothing in the part AS to resemble the force of repulsion really exerting itself in the corresponding point of AN. There would be, if there were a particle of fluid in that place; but there is not. The tendency therefore of external fluid to enter there, does not resemble the tendency of the internal fluid to expand and dissipate. It is true, indeed, the discourse should be confined to points of the surface. But the internal motion must also be considered; and the great objection always remains, namely, that the obstruction at A (n° 1.) or at *n* (n° 3.) is sufficient to prevent the passage of a particle of fluid from the pole AN into the pole AS, when urged by the repulsion of the fluid in the one and the attraction of the iron in the other; and yet will not prevent the escape of a particle when one of those causes of motion is removed. Add to this, that the whole hypothesis assumes as a principle, that the resistance to escape from any point is greatet than the obstruction to motion through the pores. This is readily granted; for however great we suppose the attraction, in the limits of physical contact, it will be no obstruction to motion through the pores, because the particle is equally affected by the opposite sides of the pores; whereas, in quitting the body altogether, there is nothing beyond the body to counteract the attraction by which it is retained.

There seems something wanting to accommodate this beautiful hypothesis of Mr Æpinus to this remarkable phenomenon; and the coincidence is otherwise so complete, that we are almost obliged to conclude that it is merely a deficiency, arising from our not having a sufficient knowledge of the law of magnetic action. This is quite sufficient: For it may be strictly demonstrated, that if the magnetic action decreases in higher ratio than that of the squares of the distances, the permanency of the fluid in any particular disposition has scarcely any dependence on the particles at any sensible distance, and is effected only by the *variations* of its density (See Electricity, *Suppl.* n° 217. for a case somewhat similar). Therefore, if the fluid be so disposed, that its density may be represented by the ordinates of such a curve as is drawn in fig. 34. having its two extremities concave toward the axis, and a point of contrary flexure at A, the tendency to escape at A will be the greatest possible; and when the magnet is broken at A (n° 1.), or when the fluid has taken the arrangement represented by n° 3. it *cannot* stop there, and *must* become deficient in that part. Now, it must be acknowledged, that we are not absolutely certain that the magnetic action is in the precise inverse duplicate ratio of the distance. All that we are certain of is, that it is much nearer to it than to either the inverse simple or inverse triplicate ratio. We own ourselves rather disposed to ascribe the present difficulty to our ignorance of some circumstance, purely mathematical, overlooked, or mistaken, than to think a conjecture unfounded, which tallies so accurately with such a variety of phenomena.

We may here observe, that we are not altogether satisfied with Æpinus's form of the experiment. He did not break a magnet; he set two steel bars end to end, and touched them as one bar, making the magnetism perfectly regular; he then separated them, and found that each had two poles. But was he certain that, when joined, they made but one magnet? We have sometimes succeeded in doing this, as we thought, by the curves of iron filings; but on putting the needle with which we were examining their polarity into proper situations, we sometimes found it in the second intersection of the secondary curves, shewing that the bars were really two magnets, and not one.

On the other hand, when a piece is broken off from a magnet, the succussion and elastic tremor into which the parts are thrown, and even the bending previous to the fracture, may give opportunity to a dissipation, which could not otherwise happen. The parts should be separated by corrosion in an acid, and the gradual change of magnetism should be carefully noted. The writer of this article has made some experiments of this nature, the results of which present some curious observations: but they are not yet brought to a conclusion that is fit to be laid before the public.

85 Hypothesis of Prevot.

Mr Prevôt of Geneva, in a dissertation on the origin of magnetic forces, endeavours to give a theory which obviates the only difficulty in that of Æpinus; but it is incomparably more complex, employing two fluids, which by their union compose a third, which he calls combined fluid. There is much ingenuity, and even mathematical address, in adjusting the relative properties of those fluids. But some of them are palpably incompatible; *ex. gr.* the particles of each attract each other, but those of the other kind most strongly; yet they are both elastic like air. This is surely inconceivable.— Granting this, however, he suits his different attractions, so that a strong elective attraction of the combined fluid for iron decomposes part of the fluid in the iron, and each of its ingredients occupies opposite ends of the bar; then will the bars approach or recede, according as the near ends contain a different or the same ingredient. All this is operated without repulsion.

But the whole of this is mere accommodation, like Æpinus's, but so much more complex, that it requires very intense contemplation to follow the author through the consequences. Add to this, that his attractions are operated by another fluid, infinitely more subtle than either of those already mentioned, every particle of these being, as it were, a world in comparison of those of the other. In short, he adopts all the extravagant suppositions of Le Sage of Geneva, and every thing is ultimately impulsion. Nor is the contrivance for obviating the difficulty (so often mentioned) at all clear and convincing; and it is equally gratuitous with the rest. We cannot think this hypothesis at all intitled to the name of *explanation*.

86 Remarks on hypotheses.

This must serve for an account of the hypothesis of Æpinus. The philosophical reader will see, that however exactly it may tally with every phenomenon, it cannot be called an explanation of the phenomena; because it is the phenomena which explain the hypothesis, or give us the characters of the magnetic fluid, if such

ſuch fluid exiſts. But we are not obliged to admit this exiſtence, as we admit that to be the true decyphering of a letter which makes ſenſe of it. In that caſe we know both parts of the ſubject—the characters and the ſounds; but are ignorant which correſponds to which. Did we ſee a fluid abſtracted from one part of a bar and conſtipated in another, and perceive the abſtraction and conſtipation always accompanied by the obſerved attractions and repulſions, the rules of philoſophical diſcuſſion, nay, the conſtitution of our own mind, would oblige us to aſſign the one as the cauſe or occaſion of the other. But this important circumſtance is wanting in the preſent caſe. We think, however, that it merits a cloſe attention; and we entertain great hopes of it being one day completed, by including this ſingle exception.

At the ſame time, it muſt be owned, that it gives no extenſion of knowledge; for it can have no greater extenſion than the phenomena on which it is founded, and cannot, without riſk of error, be applied to an untried caſe, of a kind diſſimilar in its nature to the phenomena on which it is founded. We doubt not but that its ingenious author would have ſaid, that a bit broken off from the north pole of a magnet would be wholly a north pole, if he had not known that the fact was otherwiſe.

But this hypotheſis greatly aids the imagination in conceiving the proceſs of the magnetical phenomena. The more we ſtudy them, the more do they appear to reſemble the protruſion of a fluid through the parts of an obſtructing body. It proceeds gradually. It may be, as it were, overdone, and regorges when the propelling cauſe is removed. The motion is aided by what we know to aid other obſtructed motions. As a fluid would be conſtipated in all protuberances, ſo the faculty of producing the phenomena is greater in all ſuch ſituations, &c. &c. This, joined to the impoſſibility of ſpeaking, with clearneſs of conception, of the propagation of powers without the protruſion of ſomething in which they inhere, gives it a hold of the imagination which is not eaſily ſhaken off.

To ſay that nothing is explained when the attraction of the fluid is not explained, and that this is the main queſtion, gives us little concern. We offer no explanation of this attraction, more than of the attraction of gravity. There is nothing contrary to the laws of human intellect, nothing inconſiſtent with the rules of reaſoning, in ſaying, that things are ſo conſtituted, that when two particles are together, they ſeparate, although we are ignorant of the immediate cauſe of their ſeparation. Thoſe who think that all motion is performed by impulſion, and who explain magnetiſm by a ſtream of fluid circulating round the magnet, muſt have another fluid to impel this fluid into its curvilineal path; for they inſiſt, that the planets are ſo impelled. Then they muſt have a third fluid to deflect the vertical motions of the ſecond, and ſo on without end. This is evident, and it is abſurd. But we have ſaid enough in the article IMPULSION, *Suppl.* to ſhew that all *hypotheſes* framed on purpoſe to explain action *e diſtanti* by impulſion are illogical; becauſe impulſion requires explanation as much as the other, and neither the one nor the other will ever be reſolved into any thing but the FIAT of the Allwiſe Author of the univerſe.

We conclude with deſiring the reader to remark, that the explanation which we have given of the magnetical phenomena is independent of the hypotheſis of Æpinus, or any hypotheſis whatever. We have narrated a variety of very diſtinguiſhable facts, and have marked their diſtinctions. We have been able to reduce them to general claſſes; and even to groupe thoſe claſſes into others ſtill more general; and at laſt, to point out one which is diſcoverable in them all. This is giving a philoſophical theory, in the ſtricteſt ſenſe of the word; becauſe we ſhew, in every caſe, the modification of the general fact which allots it this or that particular place in the claſſification. Thus we have ſhewn that the polarity or directive power of magnets is only a modification of the general fact of attraction and repulſion. Dr Gilbert's theory of *terreſtrial* magnetiſm is indeed a hypotheſis, and we enounced it as ſuch. It only claims probability, and we apprehend that a very high degree of credit will be given to it. 87 The pre- ding the is not a pothesis.

We hope that many of our readers will have their curioſity excited by the account we have given of Æpinus's theory. To ſuch we earneſtly recommend the ſerious peruſal of the book *Tentamen Theoriæ Electricitis et Magnetiſmi, Auct. F. Æpino, Petropoli*, 1759. Van Swinden has included a very good abſtract of it in his 2d volume *Sur l'Electricité*, written by profeſſor Steiglehner of Ratiſbon or Ingolſtadt. The mathematical part is greatly ſimplified, and the whole is preſented in a very clear and accurate manner. Mr Van Swinden is a profeſſed foe to all hypotheſes; but he is not moderate, and we wiſh that we could ſay that he is candid. He attacks every thing; and takes the opportunity of every analogy pointed out by Æpinus between magnetiſm and electricity to repeat the firſt ſentence of his diſſertation, namely, that magnetiſm and electricity are not the ſame; a thing that Æpinus alſo maintains. But he even charges Æpinus with a miſtake in his fundamental equations, which invalidates his whole theory. He ſays that Æpinus has omitted one of the acting forces aſſumed in his hypotheſis. This is a moſt groundleſs charge; and we own that we cannot conceive how Van Swinden could fall into ſuch a miſtake. We are unwilling to call it intentional, for the mere purpoſe of raiſing a man of ſtraw to knock him down again. Abbé Haüy of the French Acdemy has alſo publiſhed an abridgment of Æpinus's theory, with many excellent remarks, tending to clear the theory of the only defect that has been found in it. This work was much approved of, and recommended by the Academy. We have not had the good fortune to ſee a copy of it.

88 Analogy magneti and elec city.

The reader cannot but have remarked the cloſe analogy between the magnetical phenomena and thoſe of induced electricity; indeed, all the phenomena of attraction and repulſion are the ſame in both. The mechanical compoſition of thoſe actions produces a directive power and a polarity, in electrical as well as in magnetical bodies. We can make an electrical needle which will arrange itſelf, with reſpect to the overcharged and undercharged ends of a body electrified by mere poſition, juſt as a compaſs needle is arranged by a magnet. We can touch a ſtick of ſealing wax in the manner of the double touch, ſo as to give it poles of conſiderable force and durability. As a red hot ſteel bar acquires permanent poles by quenching it near a magnet, ſo melted wax acquires them by freezing in the neighbourhood of a poſitive

positive and negative electric. Some have inferred a sameness of origin of these two species of powers from those various circumstances of resemblance; but the original causes seem to be distinct on many accounts. Electricity is common to all bodies. The cause of magnetism can operate only on iron. Although lightning or an electrical shock gives polarity to a needle, we need not infer the identity of the cause, because the polarity which it gives is always the same with that given by great heat; and there is always intense heat in this operation. The phenomenon which looks the most like an indication of identity of the origin of electricity and magnetism is the direction of the rays of the aurora borealis—they converge to the same point of the heavens to which the elevated pole of the dipping needle directs itself. But this is by no means a sufficient foundation for establishing a sameness. Electricity and magnetism may, however, be related by means of some powers hitherto unknown. But we are decidedly of opinon, that the electric and magnetic fluid are totally different, although their mechanical actions are so like that there is hardly a phenomenon in the one which has not an exact counterpart in the other. But we see them both operating, with all their marks of distinction, in the same body; for iron and loadstones may be electrified, like any other body, and their magnetism suffers no change of modification. We can set these two forces in opposition or composition, just as we can oppose or compound gravity with either. While the iron filings are arranging themselves round a magnet, the mechanical action of electricity may be employed either to promote or hinder the arrangement. They are therefore distinct powers, inherent in different subjects.

S) ...ey are ...t, however, effects the same ...use.

But there are abundance of other phenomena which shew this diversity. There is nothing in magnetism like a body overcharged or undercharged *in toto*. There is nothing which indicates the presence of the fluid to the other senses—nothing like the spark, the snap, the visible dissipation; because the magnetic fluid enters into no union with air, or any thing but iron. There is nothing resembling that inconceivably rapid motion which we see in electricity; the quickest motion of magnetism seems inferior (even beyond comparison) with the slowest motion along any electric conductor. Therefore there is no possibility of discharging a magnet as we discharge a coated plate. Indeed, the resemblance between a magnet and a coated plate of glass is exceedingly slight. The only resemblance is between the magnet and an inconceivably thin stratum of the glass, which stratum is positive in one side and negative in the other. The only perfect resemblance is between the induced magnetism of common iron, and the induced electricity of a conductor.

The following seem the most instructive dissertations on magnetism, either as valuable collections of observations, or as judicious reasonings from them, or as the speculations of eminent or ingenious men concerning the nature of magnetism.

Gilbertus de Magnete, Lond. 1600, fol.

Æpini Tentamen Theoriæ Magn. et Electr.

Eberhard's Tentam. Theor. Magnetismi, 1720.

Dissertations sur l'aimant, par du Fay, 1728.

Muschenbroek Dissert. Physico Experimentalis de Magnete.

Pieces qui ont emportè le prix de l'Acad. des Sciences à Paris sur la meilleure construction des Boussoles de declination. Recueil des pieces courounèes, tom. v.

Euleri opuscula, tom iii. continens Theoriam Magnetis, Berlin, 1751.

Æpini Oratio Academica, 1758.

Æpini item Comment. Petrop. nov. tom. x.

Anton. Brugmanni tentam. Phil. de materia Magnetica, Francqueræ, 1765.

There is a German translation of this work by Eisenbach, with many very valuable additions.

Scarella de Magnete, 2 tom. fol.

Van Swinden Tentamina Magnetica, 4to.

Van Swinden sur l'Analogie entre les phenomenes Electriques et Magnetiques, 3 tom. 8vo.

Dissertation sur les Aimans artificielles par Antheaume.

Experiences sur les Aimans artificielles par Nicholas, Fus, 1782.

Essai sur l'Origine des Forces Magnetiques par Mr Prevost.

Sur les Aimans artificielles par Rivoir, Paris 1752.

Dissertatio de Magnetismo par Sam. Klingenstier et Jo. Brander, Holm, 1752.

Description des Courants Magnetiques, Strasbourg, 1753.

Traitè de l'Aiman par Dalancè, Amst. 1687.

Besides these original works, we have several dissertations on magnetical vortices by Des Cartes, Bernoulli, Euler, Du Tour, &c. published in the collections of the works of those authors, and many dissertations in the memoirs of different academies; and there are many popular treatises by the traders in experimental philosophy in London and Paris. Dr Gown Knight, the person in Europe who was most eminently skilled in the knowledge of the phenomena, also published a dissertation intitled, *An attempt to explain the Phenomena of Nature by two principles, Attraction and Repulsion*, Lond. 1748, 4to, in which he has included a theory of magnetism. It is a very curious work, and should be studied by all those who have recourse without scruple to the agency of invisible fluids, when they are tired of patient thinking. They would there see what thought and combination are necessary before an invisible fluid can be really fitted for performing any office we choose to assign it. And they will get real instruction as to what services we may expect of such agents, and from what tasks they must be excluded. The Doctor's theory of magnetism is very unlike the rest of the performance; for he does not avail himself of the vast apparatus of propositions which he had established, and adopts without any nice adjustment the most common notions of an impulsive vortex. Both the production and maintenance of this vortex, and its mode of operation, are irreconcileable with the acknowledged laws of impulsion.

Si quid novisti rectius istis, candidus imperti—si non—his utere mecum.

APPENDIX.

Investigation of the magnetic curve.

We have been favoured with the following investigation of the curves, to which a needle of indefinite minuteness will be a tangent, by Mr Playfair, Professor of Mathematics in the University of Edinburgh.

Two magnetical poles being given in pofition, the force of each of which is fuppofed to be as the *m*th power of the diftance from it reciprocally, it is required to find a curve, in any point of which a needle (indefinitely fhort) being placed, its direction, when at reft, may be a tangent to the curve?

1. Let A and B (fig. 35.) be the poles of a magnet, C any point in the curve required; then we may fuppofe the one of thefe poles to act on the needle only by repulfion, and the other only by attraction, and the direction of the needle, when at reft, will be the diagonal of a parallelogram, the fides of which reprefent thefe forces. Therefore, having joined AC and BC, let AD be drawn parallel to BC, and make $\frac{1}{AC^m} : \frac{1}{BC^m} :: AC : AD$; join CD, then CDF will touch the curve in C.

2. Hence an expreffion for AF may be obtained. For, by the conftruction, $AD = \frac{AC^{m+1}}{BC^m}$, and fince $BC : AD :: BF : FA$, and $BC - AD : AD :: AB : AF$, we have $AF = \frac{AB \times AC^{m+1}}{BC^{m+1} - AC^{m+1}}$.

3. A fluxionary expreffion for AF may alfo be found in terms of the angles CAB, ABC. In CF take the indefinitely fmall part CH, draw AH, BH, and from C draw CL perpendicular to AH, and CK to BH. Draw alfo BC and AM at right angles to FH. Let the angles $CAB = \varphi$, and $CBA = \psi$; then $CAH = \dot{\varphi}$, and $CBH = -\dot{\psi}$; alfo $CL = AC \times \dot{\varphi}$, and $CK = -BC \times \dot{\psi}$. Now $HC : CL :: AC : AM = \frac{AC^2 \times \dot{\varphi}}{HC}$; and for the fame reafon $BC = -\frac{BC^2 \times \dot{\psi}}{HC}$. Therefore fince $AF : FB :: AM : BC$, $AF : FB :: \frac{AC^2 \times \dot{\varphi}}{HC} : -\frac{BC^2 \times \dot{\psi}}{HC}$, and $AF : AB ::$ fin. $\psi^2 \dot{\varphi} : -$ fin. $\psi^2 \dot{\varphi} -$ fin. $\varphi^2 \dot{\psi}$; wherefore if $AB = a$, $AF = \frac{-a \dot{\varphi} \text{ fin. } \psi^2}{\dot{\psi} \text{ fin. } \varphi^2 + \dot{\varphi} \text{ fin. } \psi^2}$.

4. If this value of AF be put equal to that already found, a fluxionary equation will be obtained, by the integration of which the curve may be constructed. Becaufe $AF = \frac{AB \times AC^{m+1}}{Bc^{m+1} - Ac^{m+1}}$; and fince $AC = \frac{a \text{ fin. } \psi}{\text{fin } (\varphi + \psi)}$, and $BC = \frac{a \text{ fin. } \varphi}{\text{fin. } (\varphi + \psi)}$, we have by fubftitution $AF = \frac{a \text{ fin. } \psi^{m+1}}{\text{fin. } \varphi^{m+1} - \text{fin. } \psi^{m+1}} = -\frac{a \dot{\varphi} \text{ fin. } \psi^2}{\dot{\psi} \text{ fin. } \varphi^2 + \dot{\varphi} \text{ fin. } \psi^2}$. Hence, fin. $\varphi^2 \times \dot{\psi}$ fin. $\psi^{m+1} + \dot{\varphi}$ fin. $\psi^{m+3} = -$ fin. $\psi^2 \times \dot{\varphi}$ fin. $\varphi^{m+1} + \dot{\varphi}$ fin. ψ^{m+3}, and therefore $\dot{\psi}$ fin. $\psi^{m-1} = -\dot{\varphi}$ fin. φ^{m-1}; and alfo, $\int \dot{\psi}$ fin. $\psi^{m-1} + \int \dot{\varphi}$ fin. $\varphi^{m-1} = C$.

5. Thefe fluents are eafily found when m is any whole pofitive number.

If $m = 1$, we have $\dot{\psi} + \dot{\varphi} = o$
$m = 2$, $\dot{\psi}$ fin. $\psi + \dot{\varphi}$ fin. $\varphi = o$
$m = 3$, $\dot{\psi}$ fin. $\psi^2 + \dot{\varphi}$ fin. $\varphi^2 = o$
$m = 4$, $\dot{\psi}$ fin. $\psi^3 + \dot{\varphi}$ fin. $\varphi^3 = o$
Therefore, &c.

Alfo if $m = 1$, $\varphi + \psi = C$
$m = 2$, cof. $\varphi +$ cof. $\psi = C$
$m = 3$, $-$ fin. $2\varphi + 2\varphi -$ fin. $2\psi + 2\psi = C$
$m = 4$, cof. $3\varphi - 9$ cof. $\varphi +$ cof. $3\psi - 9$ cof. $\psi = C$, &c. &c.

The firft of the above equations belongs to a fegment of a circle defcribed upon AB, which therefore would be the curve required if the magnetical force were inverfely as the diftances.

If the magnetical force be inverfely as the fquare of the diftance, that is, if $m = 2$, cof. $\varphi +$ cof. ψ is equal to a conftant quantity. Hence if, befide the points A and B, any other point be given in the curve, the whole may be defcribed. For inftance, let the point E (fig. 36.) be given in the curve, and in the line DE which bifects AB at right angles. Defcribe from the centre A a circle through E, viz. QER; then AD being the cofine of DAE to the radius AE, the fum of the cofines of $\varphi \times \psi$ will be everywhere (to the fame radius) $= 2\,AD = AB$. Therefore to find E′, the point in which any other line AN, making a given angle with AB, meets the curve, draw from N, the point in which it meets the circumference of the circle QER, NO, perpendicular to AB, fo that AO may be the cofine of NAO, and from O toward A take OP = AB, then AP will be the cofine of the angle ABE′; fo to find BE′, draw PQ perpendicular to AP, meeting the circle in Q; join AQ, and draw BE′ parallel to AQ, meeting AE′ in E′, the point E′ is in the curve. In this way the other points of the curve may be found.

The curve will pafs through B, and will cut AB at an angle of which the cofine = RB. If then E be fuch, that AE = AB, the curve will cut AB at right angles. If E″ be more remote from A, the curve will make with AB an obtufe angle toward D; in other cafes it will make with it an acute angle.

A conftruction fomewhat more expeditious may be had by defcribing the femicircle AFB, cutting AE in F, and AE′ in N, and defcribing a circle round A, with the diftance AL = 2 AF, cutting AE′ in *b*. If AG be applied in the femicircle AFB = N*b*, AG muft cut AN in a point E′ of the curve, becaufe AN + BG = 2 AF, and AN and GB are cofines of the angles at A and B.

As the lines AN and BG may be applied either above or below AB, there is another fituation of their interfection E′. Thus A*n* being applied above, and B*g* below, the interfection is in *e*′. The curve has a branch extending below A; and if D*e* be made = DE, and B*e* be drawn, it will be an affymptote to this branch. There is a fimilar branch below B. But thefe portions of the curve evidently fuppofe an oppofite direction of one of the two magnetic forces, and therefore have no connection with the pofition of the needle.

We omitted the inferting in its proper place, n° 65. Addition to
a hypothefis of the celebrated aftronomer Tobias Mayer n° 65.
of Gottingen, by which the direction of the mariner's needle in all parts of the earth may be determined. He fuppofes that the earth contains a very powerful magnet of inconfiderable dimenfions, which arranges the needle according to the known laws of magnetifm. The centre of this magnet was diftant from the centre of the earth about 480 Englifh miles in 1756, and a line joining thefe centres interfected the earth's furface in a point fituated in 17° N. Lat. and 183° E. Long. from London. The axis of the magnet is perpedicular to this line, and the plane in which it lies is inclined about 11° to the plane of the meridian, the north end of the axis lying on the eaft fide of that meridian. From thefe data, it will be found that the axis of this magnet cuts the furface

furface of the earth about the middle of the eaftern fhore of Baffin's Bay, and in another point about 800 miles S.S.W. of the fouthern point of New Zealand. Profeffor Lichtenberg of Gottingen, who gives this extract from the manufcript, fays, that the hypothefis is accompanied by a confiderable lift of variations and dips calculated by it, and compared with obfervations, and that the agreement is very remarkable. He gives indeed a dozen inftances in very different regions of the earth. But we fufpect that there is fome error or defect in the data given by him, becaufe the annual changes, which he alfo gives, are fuch as are inconfiftent with the data, and even with each other. He fays, that the diftance from the centre increafes about four miles annually, and that *thence* arifes an annual diminution of 8 minutes in the latitude and 14 in the longitude of that point where the ftraight line joining the centres meets the furface. It can have no fuch confequence. He fays alfo, that the above mentioned inclination of the planes increafes 8 minutes annually. The compound force of the magnet is faid to be as the fquare root of the diftance inverfely. We are at a lofs to underftand the meaning of this circumftance; becaufe Mayer's hypothefis concerning the law of magnetic action is exceedingly different, as related by Mr Lichtenberg from the fame manufcript. But it was our duty to communicate this notice, though imperfect, of the fpeculations of this celebrated mathematician. See *Exliben's Elem. of Nat. Phil.* publifhed by Lichtenberg 1784, p. 645.

Addition to n° 64.

Addition to n° 64. Let HZOF (fig. 37.) be the plane of a magnetic meridian, H n'O the plane of the horizon, and NS the pofition of the magnetic needle in any place, when it is at liberty to fettle in the true magnetic direction. The angle HON is the inclination or dip of the needle. Let Z n F be a vertical circle, in which a well conftructed dipping needle can freely play up and down. This needle cannot place itfelf in the magnetic direction, becaufe it can only move in a vertical plane. Its north point is impelled in the direction $n\,o$, and its fouth point in the direction $s\,p$, both of which are parallel to NS. By the laws of mechanical equilibrium, it cannot reft, except in fuch a pofition that the forces $n\,o$ and $s\,p$ are in a plane perpendicular to the plane Z n F. In any other pofition, there would be a force impelling the needle toward that fide on which $n\,o$ makes an acute angle with the tangent $r\,n\,t$ of the vertical circle. Therefore the fpherical triangle N n F is right angled in n, and Cof. NF n : R = Tan. n F : Tan. NF, = Tan. HN : Tan. $n'n$. Therefore

$$\text{Tan. } n'n = \frac{\text{Tan. HN}}{\text{Cof. H}\,n}, = \text{Tan. HN} \times \text{Sec. H}\,n'.$$

Therefore, in any place, the real inclination of the magnetical direction to the horizon is different from what is pointed out by a dipping needle when it is in a plane which declines from the magnetic meridian; and the tangent of the obferved dip of the needle exceeds that of the inclination of the magnetic direction in the proportion of radius to the cofine of the deviation HC n', or the proportion of the fecant of this angle to the radius. If therefore the dipping needle play in a magnetic eaft and weft circle, it will ftand perpendicular to the horizon.

Malefherbes. MALESHERBES (Chriftian William de Lamoignon) was born December the 6th 1721. At the age of 24 he became a counfellor of Parliament, and fix years afterwards chief prefident of the *cour des aides*. He remained in that important fituation during a period of 25 years, and difplayed on many occafions proofs of firmnefs, eloquence, and wifdom.

When the prince of Condé was fent by the king in 1768 to filence the magiftrates who oppofed the taxes, Malefherbes replied to him, "Truth, Sir, muft indeed be formidable, fince fo many efforts are made to prevent its approach to the throne." About the fame time that he became prefident of the *cour des aides*, he was appointed by his father, then chancellor of France, fuperintendant of the prefs; an office of the greateft importance, of which the principles which Malefherbes had imbibed from D'Alembert rendered him very ill qualified to difcharge the duties. He was what the French called a *philofopher*; a term with them of the fame import with a naturalift, who openly denies revealed religion, and has no adequate notions of the moral attributes of God. The confequence was, that when the authors of impious and immoral books were brought before him in his official capacity to undergo examination, he appeared to them as advifing, affifting, and protecting them, againft that very power which was vefted in himfelf; and they were commonly difmiffed with the fenfelefs obfervation, that all books of whatever tendency fhould be confidered merely as *objects of commerce.* Had it not been for the protecting influence of Malefherbes, the *Encyclopedie*, of which the publication was frequently fufpended (fee DIDEROT in this *Supplement*), would probably have been altogether fuppreffed; and the works of Rouffeau and Raynal, which fo powerfully contributed to that revolution in which he was overwhelmed, would certainly not have fpread fo rapidly over the kingdom of France. It was he, faid D'Alembert, who *broke the fhackles of literature.*

In vain will it be replied, that he left the fame liberty to the religious as to the impious writers; for that was not always ftrictly true. The Abbé Barruel has brought the teftimony of D'Alembert himfelf to prove, that it was much againft his will that Malefherbes fuffered works refuting the fophifters to appear; and, as he very properly obferves, what a minifter allows with reluctance, he finds abundant means of preventing.

In 1775 he refigned the office of chief prefident of the *cour des aides*, and was appointed minifter and fecretary of ftate in the place of La Vrillière. Thus placed in the centre of a frivolous yet brilliant court, Malefherbes did not in the leaft deviate from his former fimplicity of life and manners; but, defpifing the eftablifhed etiquette which required magiftrates, when they became minifters of ftate, to exchange their fable habit and head-drefs for a coloured fuit, bag-wig, and fword, he retained his black coat and magifterial *peruke!* This is recorded by a panegyrift to his honour; but we perceive not the honour which it reflects on him. It ſurely requires no great powers of abſtraction to diſcover, that a coloured coat, bag-wig, and ſword, are not in themſelves more frivolous or contrary to nature, than a black coat and enormous peruke; and if the manners of a country have appropriated theſe different dreſſes to different ſtations in life, the individual muſt be actuated by a very abſurd kind of pride, who ſets up his own caprice againſt the public opinion.

As, when inveſted with the power to reſtrain within juſt limits the freedom of the preſs, it was his chief aim to encourage and extend that freedom; ſo, when raiſed to an office which gave him the unlimited power of iſſuing *lettres de cachet*, it was their total ſuppreſſion that became the earlieſt object of his *moſt ardent* zeal. Till that time *lettres de cachet*, being conſidered as a part of the general police, as well as of the royal prerogative, were iſſued not only at the will of the miniſter, but even at the pleaſure of a common clerk, or perſons ſtill more inſignificant. Maleſherbes began by relinquiſhing himſelf this abſurd and iniquitous privilege. He delegated the right to a kind of tribunal, compoſed of the moſt upright magiſtrates, whoſe opinion was to be unanimous, and founded upon open and well eſtabliſhed facts. He had but one more object to attain, and that was to ſubſtitute a legal tribunal in the place of that which he had eſtabliſhed; and this object he was upon the point of accompliſhing, when the intrigues of the court procured the diſmiſſion of Turgot; and Maleſherbes, in conſequence, reſigned on the 12th of May 1776. For this part of his conduct he is intitled to praiſe, which we feel not ourſelves inclined to withhold from his memory. Even M. Barruel admits, that he had many moral virtues, and that he diſplayed real benevolence when alleviating the rigours of impriſonment, and remedying the abuſe of *lettres de cachet*; but France, ſays he, ſhall nevertheleſs demand of him her temples that have been deſtroyed; for it was he who, above all other miniſters, abuſed his authority to eſtabliſh in that kingdom the reign of impiety.

After this epoch he undertook ſeveral journeys into different parts of France, Holland, and Switzerland, where he collected with zeal and taſte objects of every kind intereſting to arts and ſciences. As he travelled with the ſimplicity and economy of a man of letters, who had emerged from obſcurity for the purpoſe of making obſervations and acquiring knowledge, he by that means was enabled to reſerve his fortune for important occaſions, in which it might procure him information on intereſting ſubjects. He travelled ſlowly, and frequently on foot, that his obſervations might be the more minute; and employed part of his time in ſuitably arranging them. Theſe obſervations formed a valuable collection of intereſting matter relative to the arts and ſciences, but which has been almoſt totally deſtroyed by the fury of revolutioniſts, who have done as much prejudice to the intereſts of ſcience as of humanity.

Returning from his travels, Maleſherbes for ſeveral years enjoyed a philoſophic leiſure, which he well knew how to direct to uſeful and important objects. The two treatiſes which he compoſed in the years 1785 and 1786 on the civil ſtate of the proteſtants in France are well known. The law which he propoſed in theſe, was only preparatory to a more extenſive reform; and theſe treatiſes were to have been followed up by another work, the plan of which he had already laid down, when affairs growing too difficult to be managed by thoſe who held the reigns of government, they were compelled to call him to their councils. They did not, however, aſſign him the direction of any department, and introduced him merely (as ſubſequent events have ſhewn) to cover their tranſactions under a popular name, and paſs them on the world as acts in which he had taken part. Maleſherbes accepted their overtures merely to ſatisfy the deſire he felt to reveal ſome uſeful truths; but it was not for that purpoſe that they had invited him to their councils. Thoſe who preſided at them took umbrage at his firſt efforts to call their attention to the voice of truth and wiſdom; and ſucceeded ſo well in their oppoſition, that he was reduced to the neceſſity of delivering in writing the counſel which he wiſhed to offer. Such was the origin of two treatiſes relative to the calamities of France, and the means of repairing them. He tranſmitted theſe treatiſes to the king, who never read them; nor was he ever able to obtain a private audience although a miniſter of ſtate.

Such is the account of his laſt conduct in office which is given by his friends; and as we have not read his treatiſes on the calamities of France, we have no right to controvert it. From his known principles, however, we are intitled to conclude, that his plans of reformation were ſimilar to thoſe of Neckar, the offſpring rather of a head teeming with viſionary theories, than of the enlightened mind of a practical ſtateſman, or the corrupt heart of a Jacobin conſpirator.

Perceiving the inutility of his endeavours, diſguſted with what he thought the repeated errors of the government, and deprived of every means of expoſing them, or preventing their fatal effects; after frequent ſolicitations, he at length obtained leave to retire. He repaired to his eſtate at Maleſherbes, and from that moment entirely devoted his time to thoſe occupations that had ever formed the chief pleaſure of his life. He paſſed the evenings and a great part of the night in reading and ſtudy.

In this tranquil ſtate he was paſſing the evening of his days amidſt his woods and fields, when the horrors of the Revolution brought him again to Paris. During the whole of its progreſs, he had his eyes conſtantly fixed on his unhappy ſovereign, and, ſubduing his natural fondneſs of retirement, went regularly to court every Sunday, to give him proofs of his reſpect and attachment. He impoſed it as a duty on himſelf to give the miniſters regular information of the deſigns of the regicide faction *; and when it was determined to bring the king to trial, he voluntarily offered to be the defender of his maſter, in his memorable letter of the 11th of December 1792, that eternal monument of his loyalty and affection. His offer was accepted; and he pleaded the cauſe of the monarch with a ſtrength of argument that nothing could have reſiſted but the bloodthirſty minds of a den of Jacobins. "What Frenchman (ſays a valuable writer), what virtuous man of any country, can never forget that affecting ſcene, when the reſpectable old man, penetrating, for the firſt time, into the priſon of the Temple, melted into tears, on finding himſelf preſſed in the arms of his king; and that ſtill more affecting ſcene, when, entruſted with the moſt agonizing commiſſion that a ſubject could poſſibly have to his ſovereign, he threw himſelf at the feet of the innocent victim, while, ſuffocated with his ſobs, his voice, till

* *Bertrand's Memoirs*, vol iii. chap. 31.

Malesherbes.

till re-animated by the courage of the virtuous Louis, was inadequate to announce the fatal sentence of death*."

Having discharged this painful and hazardous duty he once more returned to his country residence, and resumed his tranquil course of life. But this tranquillity was of short duration. About a twelvemonth afterwards, in the month of December 1793, three worthy members of the Revolutionary Committee of Paris came to reside with him, his son-in-law, and his daughter, and apprehended the two latter as criminals. Left alone with his grandchildren, Malesherbes endeavoured to console the rest of his unfortunate family with the hopes which he himself was far from entertaining, when, the next day, the new formed guards arrived to apprehend him, and the whole of his family, even the youngest infants. This circumstance spread a general consternation throughout the whole department; for there was hardly a man in France, a few ex-jesuits excepted, who did not revere the mild virtues of the last friend of the unfortunate king.

In this calamity Malesherbes preserved the undisturbed equanimity of virtue. His affability and good humour never forsook him, and his conversation was as usual; so that to have beheld him (without noticing his wretched guards), it seemed that he was travelling for his pleasure with his neighbours and friends. He was conducted the same night to the prison of the Madelonette with his grandson Louis Lepelletier, at the same time that his other grandchildren were separated into different prisons. This separation proving extremely afflicting to him, he earnestly solicited against it; and at length, on his repeated entreaties, they all met together once more at Port-Libre. They remained there but a short period. The son-in-law of Malesherbes, the virtuous Lepelletier Rasambo, the first of them who was arrested, was ordered into another prison, and sacrificed a few days after. Malesherbes himself, his daughter, his grand-daughter, and her husband, were soon after all brought to the guillotine. They approached it with fortitude and serenity. It was then that his daughter addressed these pathetic words to Mademoiselle Sombreuil, who had saved the life of her own father on the 2d of September: "You have had the exalted honour to preserve *your* father—I have, at least, the consolation to die with *mine*."

Malesherbes, still the same, even to his last moments exhibited to his relations an example of fortitude. He conversed with the persons that were near him without bestowing the least attention on the brutalities of the wretches who tied his hands. As he was leaving the prison to ascend the fatal cart, he stumbled against a stone, and made a false step. "See (said he smiling), how bad an omen! A Roman in my situation would have been sent back again." He passed through Paris, ascended the scaffold, and submitted to death with the same unshaken courage. He died at the age of 72 years, 4 months, and 15 days. He had only two daughters; and the son of one of them alone remains to succeed. From this account of Malesherbes's behaviour at his last moments, we are inclined to believe that his intentions were better than some parts of his practical conduct; and we know, that having dispelled the vain illusions of philosophism, he acknowledged his past errors; exclaiming, in the accents of grief, "That false philosophy (to which I confess I was myself a dupe) has plunged us into the gulph of destruction, and, by an inconceivable magic, has fascinated the eyes of the nation, and made us sacrifice reality to a mere phantom. For the simple words *political liberty*, France has lost that *social freedom* which she possessed in every respect, in a higher degree, than any other nation! How truly great did the king appear in his last moments! All their efforts to degrade him were vain; his unshaken virtue triumphed over their wickedness. It is true, then, that religion alone transfuses sufficient courage into the mind of man, to enable him to support, with so much dignity, such dreadful trials †."

* Clery's Journal, p. 5—195.

† Bertrand's Memoirs, chap. 40.

Malguzzary.

MALGUZZARY, in the language of Bengal, *payment* of revenue; the *revenue* itself.

Malphaghino.

MALPHAGHINO (John), otherwise called John de Ravenna, from the place of his birth, was born in the year 1352, of a family distinguished neither by riches nor nobility. His father, however, committed him to the care of Donatus the grammarian, an intimate friend of Petrarch, who at that time taught the Latin tongue with great applause at Venice. Donatus thought he discovered such happy dispositions in young Malphaghino, that he recommended him to Petrach, not only as an excellent assistant to facilitate his labours, by reading or transcribing for him, but as a youth of the most promising talents, and worthy of being formed under the inspection of the greatest man of the fourteenth century.

It appears from some of Petrarch's letters, for it is from these chiefly we can obtain information respecting John de Ravenna, that he fully answered the expectations formed of him; and that he even gained the favour and affection of his patron so much, that he loved him and treated him as if he had been his own son. In a letter to John de Certaldo (A), Petrarch highly extols him, not only for his genius and talents, but also for his prudent and virtuous conduct. "He possesses (says he) what is very rare in our times, a great turn for poetry, and a noble desire to become acquainted with every useful and ornamental part of knowledge. He is favoured by the Muses, and already attempts verses of his own; from which one can foretel, that, if his life be spared, and if he goes on as hitherto, something great may be expected from him."

Not long, however, after this panegyric was written, young Malphaghino conceived an insuperable desire to see the world; and, notwithstanding all Petrarch's remonstrances, persisted in his resolution of quitting him. Petrarch's paternal care and regard for his pupil appear, on this occasion, in the most favourable light, as may be seen in his letters to Donatus; and his whole behaviour, though the young man insisted on leaving him, without assigning a sufficient reason for his precipitate and ungrateful conduct, does as much honour to his head as to his heart.

The precipitation with which John de Ravenna carried his plan into execution was not likely to make it answer his expectations. He departed without taking with him letters of recommendation which Petrarch offered him to his friends. He, however, pursued his journey over the Appenines, amidst continual rain, giving out that he had been dismissed by Petrarch; but, though he experienced from many a compassion to which he was not entitled by his conduct, he now began to awaken from his dream. He proceeded therefore to Pisa,

(A) Better known under the name of *Boccaccio* or *Boccace*. Certaldo was the place of his birth.

Malphaghino.

Pisa, in order to procure a vessel to carry him back towards Pavia; but being disappointed, while his money wasted as much as his patience decreased, he suddenly resolved to travel back across the Appenines. When he descended into the Ligurian planes, he attempted to wade through a river in the district of Parma, which was much swelled by the rains; and being carried by the force of the stream into a whirlpool, he would have lost his life, had he not been saved by some people who were accidentally passing that way. After escaping this danger, he arrived, pennyless and famished, at the house of his former patron, who happened then not to be at home; but he was received and kindly entertained by his servants till their master returned.

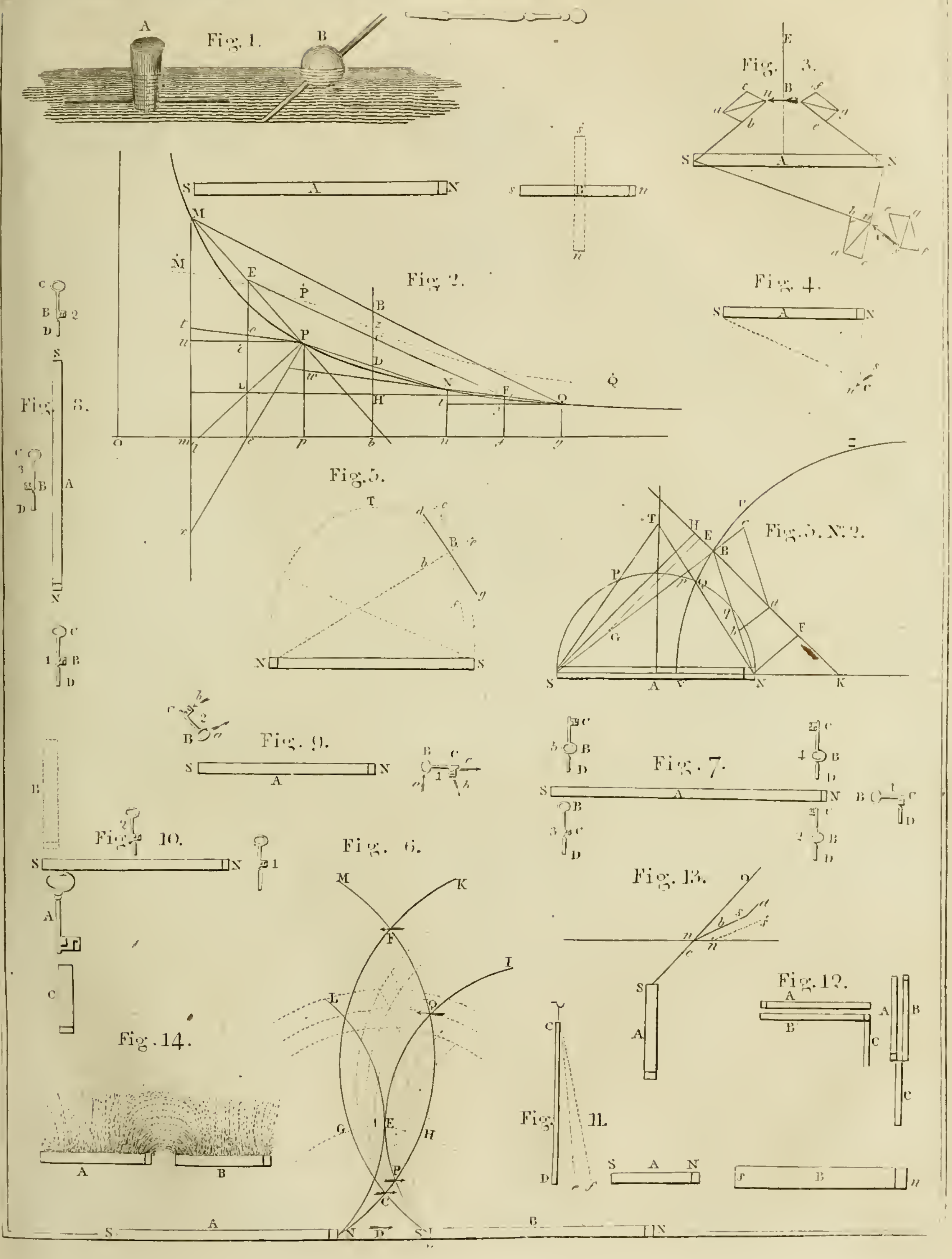
Petrarch, by his intreaties and paternal admonitions, retained the young man at his house for about a year, and prevented him from engaging in any more romantic adventures; but, at the end of that period, his desire for rambling again returned; and as Petrarch found that all attempts to check him would be fruitless, he gave him letters of recommendation to two of his friends, Hugo de St Severino and Franciscus Brunus, at Rome. To the former of these, Petrarch says, "This youth of rare talents, but still a youth, after proposing to himself various plans, has at length embraced the noblest; and as he once travelled, he is now desirous of doing so again, in order to gratify his thirst of knowledge. He has, in particular, a strong inclination for the Greek language; and entertains a wish which Cato first conceived in his old age. This wish I have endeavoured for some years to subdue; sometimes by intreaties, at other times by admonition; sometimes by representing how much he is still deficient in the Roman language; and sometimes by laying before him the difficulties which must attend him in his journey, especially as he once before left me, and by want was obliged to return. As long as that unfortunate excursion was fresh in his memory he remained quiet, and gave me hopes that his restless spirit could be overcome and restrained. But now, since the remembrance of his misfortunes is almost obliterated, he again sighs after the world; and can be retained neither by force nor persuasion. Excited by a desire which betrays more ardour than prudence, he is resolved to leave his country, friends, and relations, his aged father, and me whom he loved as a father, and whose company he preferred to a residence at home, and to hasten to you whom he knows only by name. This precipitation even has an appearance of prudence. The young man first wished to visit Constantinople; but when I told him that Greece, at present, is as poor as it was formerly rich in learning, he gave credit to my assertion, and at any rate altered his plan, which he could not carry into execution. He is now desirous of traversing Calabria, and the whole coast of Italy, distinguished formerly by the name of Magna Græcia, because I once told him that there were in that quarter several men well skilled in the Greek language, particularly a monk, Barlaam, and one Leo, or Leontius, with whom I was intimately acquainted, and of whom the first had been some time my scholar. In consequence of this proposal, he begged me to give him a recommendatory letter to you, as you have considerable influence in that part of the country. This request I granted, in hopes that the young man, by his genius and talents, will afford you satisfaction equal to the service which you may render to him." In his letter to Brunus, Petrarch expresses himself as follows: "He is a young man who wishes to see the world as I formerly did; but I never reflect on it without horror. He is desirous of seeing Rome; and this desire I cannot condemn, as I myself have so often visited that city, and could still revisit it with pleasure. I suspect, however, that he will venture on a more extensive ocean, and that he imagines to find a fortune where he will, perhaps, meet with a shipwreck. At any rate, he is desirous, he says, of putting his fortune to a trial. I wish it may be favourable; should it be adverse, he is still at liberty to return to my peaceful, though small, haven; for I hang out a light during the day as well as the night, to guide those who quit me through youthful folly, and to enable them to find their way back. The ardour by which he is impelled must not be ascribed so much to him as to his age, and is in itself commendable. If I am not much deceived, the young man loves me and virtue in general. He is unsteady, but modest; and deserves that all good men should contribute to his prosperity as far as they can."

From the letters of Petrarch, there is reason to believe, that John de Ravenna lived with him only about three years in all; and that he had not attained to the full age of manhood when he left him. It appears also, for this circumstance is very obscure, that after he quitted him, he wandered about a considerable time before he was so fortunate as to meet with a protector and patron, at whose house, as he wrote to Petrarch, he at last found a permanent asylum. How long he remained with his patron, whom some believe to have been Cardinal Philip, and what happened to him till the death of Petrarch in 1374, and for some years after, is unknown. The literary monuments of the fourteenth and fifteenth centuries say nothing farther of him till his appearance at Padua; where, according to the testimony of Sicco (B), one of the most celebrated of his scholars, he not only taught the Roman Eloquence, but also the science of moral philosophy, with such success and applause, and improved his scholars so much by his life and example, that, according to universal opinion, he far excelled all the professors of those sciences who had ever before appeared. That he was here of considerable service in reviving the study of the Latin language, and of the works of the ancient Romans, was acknowledged by all his scholars, and is confirmed by the following testimony of Blondus (C).

"About the same period, Ravenna produced that learned

(B) Adolescens tum ego poetas, et instituta Tullii audiebam. Legebat tunc hac in civitate Padua, literarum nutrice, *Johannes Ravennas*, vir et sanctimonia morum et studio isto excellens, atque si potest sine invidia, dici ceteris, qui magistri artis hujus in terra Italia usquam degerent et doctissimi haberentur, quantum recordari videor, omnium judicio præferendus. Hoc namque a præceptore non eloquentia modo, quam ex ordine legerit, sed mores etiam, ac quædam bene honesteque vivendi ratio cum doctrina tum exemplis discebatur.—*Sicco Poleutonus*, Ap. Mehus, l. c. p. 139.

(C) Blondi Flavii Forliviensis Italia illustrata. Bas. 1559. fol. p. 346.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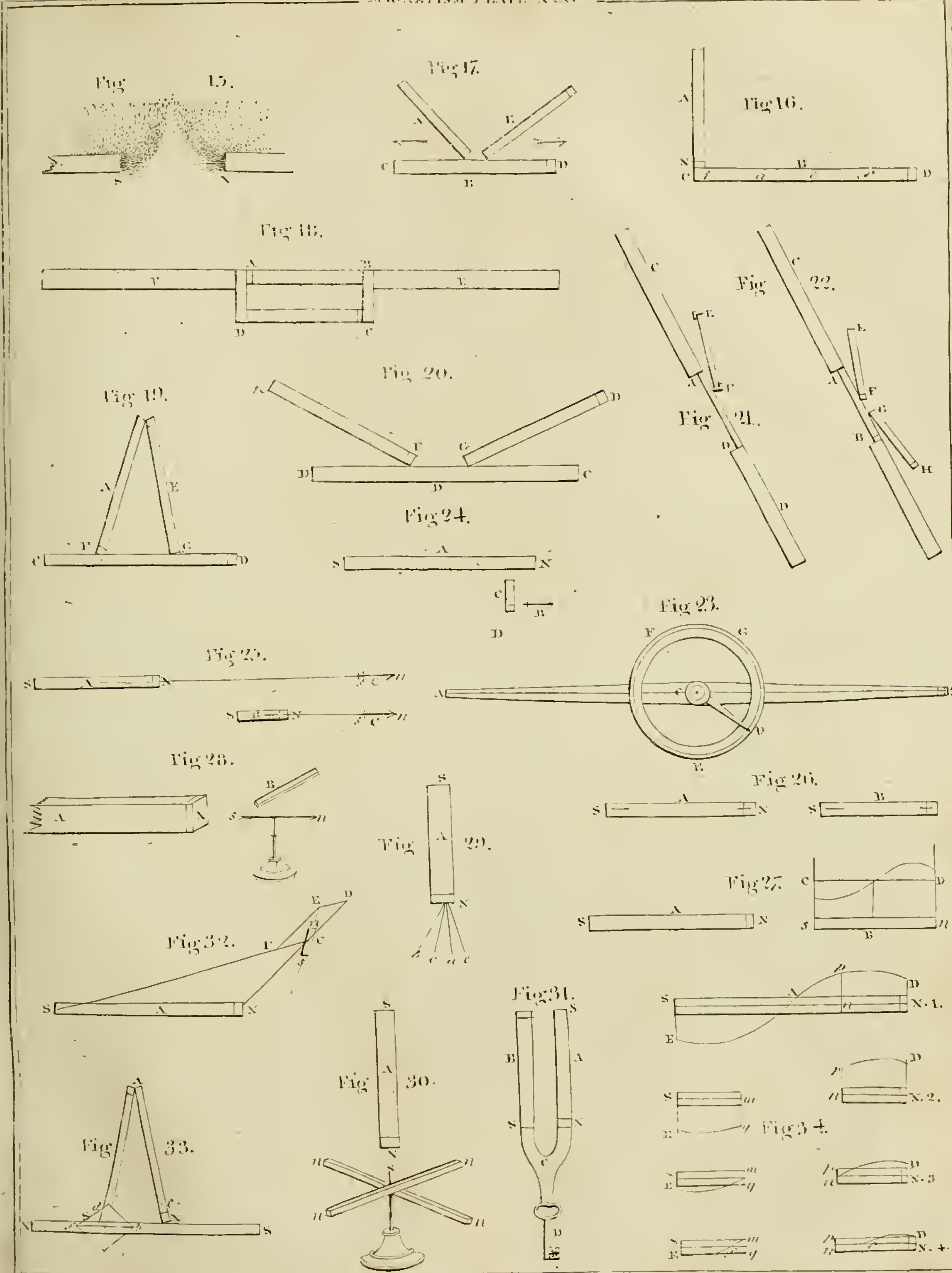
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Fig 34.

learned grammarian and rhetorician Johannes, of whom Leonardus Aretinus used to say, that he first introduced into Italy, after a long period of barbarism, the study of the latin language and eloquence, now so flourishing; a circumstance which deserves to be enlarged on in the present work. Those well acquainted with Roman literature know, that after the periods of Ambrose, Jerom, and Augustine, there were none, or very few, who wrote with any elegance, unless we add to these good writers, St Gregory, the venerable Beda, and St Bernard. Francis Petrarcha was the first who, with much genius, and still greater care, recalled from the dust the true art of poetry and of eloquence. He did not attain to the flowers of Ciceronian eloquence, with which many are adorned in the present century; but this was owing rather to a want of books than of talents. Though he boasted of having found at Vercelli Cicero's letters to Lentulus, he was unacquainted with the books of that great Roman *De Oratore*, Quintilian's Institutes, the *Orator*, the *Brutus*, and other writings of Cicero. John de Ravenna was known to Petrarch both in his youth and in his old age. He was not more conversant with the ancients than Petrarch; and, as far as I know, left no works behind him. By his excellent genius, however, and, as Leonardus Aretinus says, by the particular dispensation of God, he was the preceptor of this Leonardus, of Petrus Paulus Vergerius, of Annebonus de Padua, of Robert Rossi, of James Angeli of Florence, of Poggins and Guarino of Verona, of Victorinus, Sicco, and other men of less note, whom he incited to the study of better knowledge, and to imitate Cicero, if he could not form them or instruct them completely.

"About the same time, Manuel Chrysoloras, a man as virtuous as learned, came from Constantinople to Italy, and instructed in the Greek language, partly at Venice and partly at Florence and Rome, all the before mentioned scholars of John de Ravenna. After he had continued this instruction for some years, those unacquainted with the Greek language, and the ancient Greek writers, were considered in Italy as more ignorant than those unacquainted with the Latin. A great many young men and youths were inflamed with an enthusiastic desire for the works of the ancient Greeks and Romans. At the time of the council of Constance, in the beginning of the 15th century, many of my countrymen endeavoured, by searching the neighbouring convents and cities, to discover some of the Roman manuscripts which had been lost. Poggins first discovered a complete copy of Quintilian, which was soon followed by the letters of Cicero to Atticus. As our youth applied to the study of these works with the utmost diligence, that celebrated grammarian and rhetorician Caspanius de Bergamo, opened a school at Venice, superior to the former, and in which young persons were encouraged to study the ancient languages and writers. About the same time flourished Petris Paulus Vergerus, Leonardus Aretinus, Robert Rossi, James Angeli, Poggins, and Nicolaus de Medici, whom Aretin had long instructed. Guarinus also had begun to instruct many at Venice, and Victorinus at Mantua, when Phillip III. Duke of Milan, recalled Casparinus as his subject, from Venice to Padua and Milan. The increasing study of ancient literature was much promoted by Gerard Landriano bishop of Lodi, discovering under some ruins an old copy of Cicero, written in characters scarcely legible, which, among other rhetorical writings of that great Roman, contained the whole books *De Oratore*, with his *Brutis* and *Orator*. This saved Casparinus the trouble of supplying the books of Cicero *De Oratore*, as he had attempted to supply the works of Quintilian. As no one was found in all Milan who could read this old manuscript of Cicero, an ingenious young man of Verona, named Casmus, was so fortunate as first to transcribe the books *De Oratore*, and to fill all Italy with copies of a work which was universally sought for with the utmost avidity. I myself, in my youth, when I went to Milan on the business of my native city, transcribed, with as much ardour as speed, the *Brutus* of Cicero, and sent copies of my transcription to Guarinus at Verona, and to Leonard Justiniani at Venice; by which means this work was soon dispersed all over Italy. By these new works eloquence acquired new fire; and hence it happens, that in our age people speak and write better than in the time of Petrarch. The study of the Greek language, besides the abundance of new and useful knowledge which it disclosed, was attended with this great advantage, that many attempted to translate Greek works into Latin, and thereby improved their style much more than they could have done without that practice. After this period, schools for teaching the ancient languages increased in Italy, and flourished more and more. Most cities had schools of this kind; and it gives one pleasure to observe, that the scholars excelled their masters, not only when they left them, but even while they were under their tuition. Of the scholars of John de Ravenna, two of the oldest, Guarinus and Victorinus, the former at Venice, and the latter at Mantua, Verona, Florence, and Ferrara, instructed an immense number of pupils; and among these, the Princes of Ferrara and Mantua. George of Trebisonde, when he lectured at Rome, had for his auditors, besides Italians, many French, Spaniards, and Germans, among whom sometimes there were men of rank and eminence. Franciscus Philelphus, who had been taught at Constantinople by Chrysoloras himself, instructed a great many young men and youths in the Greek and Latin languages at Venice, Florence, Siena, Bologna, and, last of all, at Milan." In the above quotation, the share which John de Ravenna had in reviving and diffusing a knowledge, not only of the Roman, but also of the Grecian literature, is so clearly represented, that no farther testimony is necessary to establish his claim to celebrity.

After John de Ravenna had taught at Padua, he removed for the like purpose to Florence; where, as appears, he instructed young people for some time, without being expressly invited by the government, and without being publicly paid for his labours. In the beginning of his residence at Florence, he seems to have been recommended by Colucius to the learned Charles de Malatesta. "There lives here at present (says Colucius, in one of his letters) a teacher of great merit, John de Ravenna.—He is (continues he) of mature age; irreproachable in his manners, and so disposed in general, that if you receive him, as I hope and wish, among the number of your intimate friends, you will find him an agreeable and incomparable assistant to you in your labours and studies. What can be more desirable to you than to possess a man who will lucubrate and labour for you? and who, in a short time, can communicate to you what you could not obtain by your own.

own exertions without great difficulty. I do not know whether you will find his like in all Italy; and I therefore wish, that, if you confide in my judgment, you will receive John de Ravenna in the room of your late learned friend James de Alegretti." It is not known whether John de Ravenna went to reside with Malatesta or not. It is, however, certain, that the former, in 1397 (the same year in which Manuel Chrysoloras came to Florence), was invited thither by the magistrates of that city, with the promise of an annual salary, to instruct young people in the Roman language and eloquence; that John de Ravenna, at the period when he entered into this honourable engagement, was 45 years of age; and that the scholars of John de Ravenna were, at the same time, scholars of Chysoloras. Saluratus Colucius, in all probability, was the cause of this invitation, as he was acquainted with the services of John de Ravenna, and knew how to appreciate them. "We know (says he), in one of his letters to John de Ravenna), and all who respect you know also, that none of the moderns, or even ancients, approached so near to Cicero as you; and that to the most wonderful beauty and powers of speech, you join the deepest knowledge." John de Ravenna, like Chrysoloras, and most of the teachers of the Greek and Roman languages in the beginning of the fifteenth century, was, no doubt, engaged at first only for a few years; when these were elapsed, the engagement was renewed, perhaps for the last time, in 1412, and he was bound, besides teaching the Roman eloquence, to read publicly, and explain in the cathedral, on festivals, the poems of Dante. John de Ravenna did not long survive the above renewal of his engagement; for an anonymous writer, who, in 1420, finished *A Guide to Letter-writing, according to the Principles of John de Ravenna*," speaks of his preceptor as of a man not then in existence.

MALT. See BREWING (*Encycl.*), where a full account is given of Sir Robert Murray's method of malt-making, together with some valuable observations on malt by Mr Richardson of Hull. In a late edition of this latter gentleman's *Theoretic Hints on Brewing*, we are told, that Mr Edward Rigby of Norwich is of opinion, that the mere exsiccation of corn is not the only object obtainable by drying it on the kiln, but that some portion of the saccharum of malt is the effect of that process. "The operation of kiln drying the malt (says Mr Rigby) is as follows:—The grain is spread thick upon a floor made of flat bricks (*tiles*), or iron plates, which are full of perforations; immediately under this floor is the oven or furnace, in which is a large fire made of *coaks*, cinders, or, in some places, billet wood; a current of air, at the mouth of the furnace, keeps up the combustion of the coaks, and the air which is phlogisticated by their burning, and which, in a common fire-place, rises up the chimney, passes, in this instance, through the apertures in the floor, and penetrates the whole stratum of malt before it can pass into the external air. Under these circumstances, it is evident, that the interstices of the malt must be filled with phlogistic air; and as the grain usually remains in this situation about two days, it is obvious, that if it have the power of absorbing phlogiston, it certainly must do it when so long in contact with it. And that the malt does really imbibe some of this principle, is not only probable on the general ground of the truth of the preceding theory, but, I believe, it will be found, that the phlogisticated air which rises from the burning substances underneath, is corrected in passing through the malt; for without its being meliorated by this or some other cause, it is evident that the air in the kiln-chamber, more especially the lower strata of it, must be noxious, and probably even so much so as to be unfit for respiration and combustion. But so far from this being the case, I am informed, that workmen will lie and sleep many hours on the malt in this situation without suffering any inconvenience. And after mentioning this, it is scarcely necessary to add, that I find also, by experiment, that a candle will burn perfectly well in the air which is immediately on the surface of the malt.

"Were heat alone sufficient for the purpose of completing the operation of malting, it certainly might be applied in a much more cheap way than is at present done; for the floor on which the grain is laid might, unquestionably, be heated equally without there being perforations in it, as with them. In which case, one kind of fuel would be as good as another; and, consequently, the present expence of previously burning the coals, to convert them into coaks or cinders, might be saved.

"But, admitting that the application of phlogiston to the malt, as well as heat, is requisite in this operation, the necessity of these perforations becomes evident, and also the propriety of previously burning the coals in such a way, that all the water, and those other heterogeneous particles which compose smoke and soot, may be dissipated; for these, merely as such, would obviously contribute little to the phlogistication of the malt, and would evidently impart some offensive flavour, if not some obnoxious quality to it.

"Reasoning from the above premises (Mr Rigby concludes), it would seem, that as all the farinaceous parts of the barley are seldom dissolved in brewing, and the grains which are left have usually the disposition to become sour, thereby manifesting some of the acid principle to be still existing in them, it is not improbable but some further saccharine matter might be obtained from the grain by another exposure to phlogisticated air, or, in other words, by being once more laid on the kiln."

This is indeed so far from being improbable, that we think it must infallibly be the case. Sugar, it is well known, consists of oxygen, hydrogen, and carbon (see CHEMISTRY in this *Supplement*, n° 466.); but from the disposition of the grains to become sour, it is plain, that after the process of brewing they still retain much oxygen; and the azotic gas, which is here called phlogisticated air, there is every reason to believe contains both hydrogen and carbon. These, therefore, uniting with the oxygen of the grains, must make an addition to the saccharine matter. This has, indeed, been found to be the fact by Mr Richardson, who, in consequence of Mr Rigby's suggestion, was induced to brew a small brewing of malt, of ten quarters only, and stopping the process when, according to his general practice, one extract was still due, he ordered the grains to be laid upon one of his malt-kilns, and cinders to be applied the same as for drying of malt. This was continued for two days and a half, when the grains, being perfectly dried, were put into sacks, and, when cold, returned again into the mash-tun. The event, in some measure, justified Mr Rigby's

Mammalukes.

Rigby's expectation; for the produce of fermentable matter was considerably more than he had reason to conclude would have been the case, had the extract been made in immediate succession, as it would have been in the ordinary course of his practice. He attempts, indeed, to account for it in a way very different from ours; but though we have the highest confidence in Mr Richardson as an experienced brewer, we must sometimes beg leave to think for ourselves as chemists. Like a man of sense, however, and a man of science, he says, "I am so well satisfied with the event of this experiment, that I shall probably be inclined, on some future occasion, to repeat it, in various stages of the process. The fine lively froth on the surface of the wort, in the underback, added to its transparency and good flavour, are circumstances which induce me to thank Mr Rigby for the hint, which, it is not improbable, may be applied to some useful purpose, in certain situations which sometimes occur in the brewing trade."

MAMMALUKES, Mamalucs, *Mameloucs*, or *Mamluks*, were a dynasty that reigned for a considerable time in Egypt, and of which some account has been given in that article (*Encycl*) A fuller account of them must, however, be acceptable to our readers, as, since their connections with the French, they have attracted considerable attention.

Antijacobin Review, n° . and *Brown's Travels.*

They were first introduced into Egypt, as we have already observed, by Saladine, who, when he had it in contemplation to besiege Jerusalem, very naturally endeavoured to collect the most forcible means to accomplish so desirable an end; and, in consequence, observing that the ancient inhabitants of Egypt were, from their effeminate mode of education, and the quiet and tranquil habits of their lives, much fitter for those occupations in which they delighted, namely, the arts, merchandize, and mechanics, than military tactics and military toil, he resolved, as little as possible, to employ or depend upon them.

This resolution stimulating him to procure a hardier race of soldiers, he therefore commissioned agents to treat with the Circassians, by the Lake of Mæotis, near Tawrica Chersónesas, whence, about the year 1176, they purchased more than a thousand slaves. Men inured to hardship, nurtured in the lap of toil and danger, and bred from their infancy to war, which was to them rather than an instinct than a science, as the continual incursions of the Tartars rendered self-defence, in their situation, absolutely necessary.

These slaves Saladine trained to military discipline, and, at the same time that he made them renounce Christianity, had them instructed in the Mahometan religion; and although he prohibited them from marrying, he allowed them an unbounded license with respect to desultory gallantry. What progress they made in the doctrines of the Alcoran, whether the tenets of that sacred volume effectually eradicated all their first principles, is uncertain; but it is certain, that in time they became excellent soldiers, and that the military glory of Saladine, which was feebly supported by the native Egyptians, expanded in the hands of the Mamelouсs, who extended their conquests on every side, until, pervading the Holy Land, they entered in the plain of Askelon.

These Mamelouсs, who were continually adding to their numbers, in process of time became naturalized to the country; and, as it has been observed, they excelled the Egyptians in strength of body, in military discipline, in their skill in horsemanship, and in courage; so they, by the liberality of their generals, and the plunder of cities and provinces, also excelled them in wealth. In fact, their mode of education fitted them for the most dangerous and adventurous enterprises, and, from being the slaves, enabled them in time to become the masters of even the Turks, by whom they had originally been purchased.

After the death of Saladine, who left the kingdom to his brother, they rose to still greater importance than they had acquired during his reign, and continued, if not absolutely to govern, yet, like the Roman soldiers in the time of Pertinax, Alexander, and Valerian, to awe the monarch.

This influence continued through the reigns of five successive Caliphs, until that of Melachsala, the last of the posterity of Saladine, who being at war with the Arristians, and, at the same time, wishing to repress the enormous power of the Mamelouсs, purchased slaves from all the surrounding countries, whom, in imitation of his ancestor, he armed and appointed to defend his dominions. The event of this measure was exactly what might have been expected. Melachsala was, in consequence of a conspiracy betwixt his new and his old soldiers, slain; and Turquemenus, the leader of this mutiny and rebellion, hailed by the title of Great Sultan of Egypt. With him began the government of the Mamelouсs, about the year 1250; which had the next year gathered such strength, that it was thought necessary, in order to repress those exuberances to which new formed governments are liable, and bring it nearer to a system, to cause the following articles, in the form of a charter, to be subscribed to by their principal leaders, as an act of the whole people:—"1st, That the Sultan should be chosen from the body of Mamelouсs; 2dly, That none should be admitted into the order that were by birth either Jews or Turks, but only Christian captives; 3dly, That the native Egyptians should not be permitted to use, or have, any weapons, except the instruments of agriculture."

Turquemenus, as is frequently the practice with those that experience a sudden elevation, endeavoured to kick down the ladder by which he had been raised; or, in other words, his carriage was so haughty and disdainful to his former companions, that he was by them, or rather by one of them named Clotho, suddenly slain; for which the murderer was rewarded with his sceptre. After him succeeded a long race of princes, many of whom were as eminent for their talents as for their valour; among whom, the name of Caitbeius has been transmitted to us as that of the greatest statesman and general of his age; but, as every one who considers the *materials* of which the government was composed, must rather wonder that it existed so long, than that it should, through almost the whole course of its operation, be exposed to all the various evils and distresses arising from a long train of sedition and tumults, so he must lament that it should expire in the reign of one of their wisest and best monarchs: yet it is some consolation to reflect, that Campson, the last Sultan of the Mamelouсs, was not *murdered by his own subjects*, but having for many years governed the kingdoms of Egypt, Judea, and Syria, in a manner that has excited the praise of

Mammalukes.

of the hiftoric pen, he, oppreffed with age and difeafe, and encumbered with his armour, funk upon the field of battle, and, with his laft breath, yielded the victory to the fortunate Selim.

With this monarch, who expired January 20, 1516, ended the government of the Mameloucs, after it had continued 276 years; for although an attempt was made by Tomumby to get himfelf declared Sultan, in which attempt he actually fucceeded fo far as to be invefted with the title, yet he was foon after defeated by the victorious Selim. He was then forfaken by his troops, taken and executed; while the Mameloucs, broken and difperfed, it was the policy of Selim to rally, and, by offers too tempting to be by them refufed, engage in his fervice. The ufe of thefe foldiers foon became fufficiently apparent to the Turkifh Emperors, to ftimulate them to augment their number, enlarge their fphere of action, and combine them clofer to the ftate, by the allowance of ftill greater privileges and advantages than they had before enjoyed.

The Beys were ordained to be chofen from among them; and the Pafha, or chief governor for the Porte, was to fhare his power with thofe Beys, and even to continue in office no longer than fhould be agreeable to their collective will. At firft the power of the Pafha was very extenfive; but, by the intrigues and ambition of the Beys, it has been reduced almoft to a cypher. It was rather of a civil than military nature. He was always prefident of the Divan, which was held in the caftle where he refided. But that council now commonly meets in the palace of one of the chief Beys, except when a firman or mandate is received from Conftantinople, when the Beys are fummoned to the caftle, to hear the commands of the Porte. The few who attend, as foon as the reading is finifhed, anfwer, as is ufual, "*Efmana wa taana*," "We have heard, and we obey." On leaving the caftle, their general voice is "*Efmana wa awfina*," "We have heard, and fhall difobey."

In the year 1791, Salah Aga, a flave of Murad Bey, was deputed from the government of Egypt to negociate their peace with the Porte. He carried prefents of horfes, rich ftuffs, &c. A fpontaneous tribute, which the Porte was in no condition to enforce, implied obligation on the part of the latter. He was well received, and afterwards was appointed *Waquil es Sultan*, agent or attorney to the Sultan in Cairo. It is probable this office was given him to incline him to fecond the efforts of the Court in difuniting the Beys; but it was ineffectual. Thefe had formerly experienced the evils of divifion, and now were united by common intereft, grown rich, and well provided with flaves; fo that no tribute has fince that time found its way to Conftantinople.

The Mameloucs remain, as they have ever been, military flaves, imported from Georgia, Circaffia, and Mingrelia. A few have been prifoners, taken from the Auftrians and Ruffians, who have exchanged their religion for an eftablifhment. The Beys give general orders to their agents at Conftantinople to purchafe a certain number every year; and many are brought to Egypt by private merchants on fpeculation. When the fupply proves infufficient, or many have been expended, black flaves from the interior of Africa are fubftituted, and, if found docile, are armed and accoutred like the reft.

Particular attention is paid to the education of thefe favoured flaves. They are inftructed in every exercife of agility or ftrength, and are, in general, diftinguifhed by the grace and beauty of their perfons. The gratitude of the difciples is equal to the favour of their mafters, whom they never quit in the hour of danger. If they have a difpofition for learning, they are taught the ufe of letters, and fome of them are excellent fcribes; but the greater part neither can read nor write. A ftriking example of which deficiency is obfervable in Murad Bey himfelf.

The inferior Mameloucs conftantly appear in the military drefs, and are commonly armed with a pair of piftols, a fabre, and a dagger. They wear a peculiar cap of a greenifh hue, around which is wreathed a turban. The reft of their drefs refembles that of other Mahomedan citizens, and is reftricted to no particular colour; but another fingularity is, their large drawers of thick Venetian cloth, of a crimfon colour, to which are attached their flippers of red leather. On horfeback they add to their arms a pair of large horfe piftols, and the dubbus or battle-axe. In battle, many of them wear an open helmet, and the ancient ring armour of interwoven links of fteel, worn under part of their drefs, and thus concealed. Thefe are dear; fometimes cofting 500 piaftres, or about L. 40. Some of them are made at Conftantinople, others in Perfia. Their horfes are of the fineft Arabian breed, and are often purchafed at three or four purfes, L. 150 to L. 200 fterling.

They have no pay, as they eat at a table in the houfe of their mafter the Bey, Cafhef, or other officer. Any military officer may purchafe a flave, who becomes *ipfo facto* a Mamelouc. The name, from *malek*, to poffefs, implies merely a perfon who is the property of another. After a proper education, the candidate thus conftituted a Mamelouc, receives a prefent of a horfe and arms from his mafter, together with a fuit of clothes; which is renewed every year in the month Ramadan. The generofity of their mafters, and rewards or extortions from others, afford them fupplies of money, either for avarice or debauchery. Some of them, admitted to peculiar favour by the Beys, as chafnadars, or purfe-bearers, &c. acquire great wealth. They are rather gay and thoughtlefs than infolent, fond of fhow, and unprincipled in their means of acquiring it. They feldom marry till they acquire fome office.

Though born of Chriftian parents, they feem highly fatisfied with their condition, which they have been known to refufe to exchange for freedom. The majority are regarded by the Arabs as little ftrict in the principles or duties of Mohamedifm. It is worthy of remark, that though the Mameloucs, in general, be ftrong and perfonable men, yet the few who marry very feldom have children. As the fon, even of a Bey, is not honoured wirh any particular confideration, the women, perhaps, procure abortions. Of eighteen Beys, with whofe hiftory Mr Browne was well acquainted, two only had any children living.

Hardy, capable of every fatigue, of undaunted courage, and eminent fkill in horfemanfhip and the ufe of the fabre, the Mameloucs may be regarded as by far the beft troops in the Eaft. But in a regular battle, conducted by manœuvres, and large or rapid movements, they are equally inferior to European troops.

Being

Mammalukes, Man.

Being diſtinguiſhed by favouritiſm or merit, the Mameloue becomes a Caſhef, and in time a Bey. The chief cauſe of preference ariſes from political adherence to ſome powerful leader.

Before the invaſion of Egypt by the French (See *Revolution, Suppl.*), the Government of Cairo, and indeed of the whole country, was veſted in 24 Beys; but the Porte has ſince endeavoured to deprive them of all power; with what ſucceſs is not yet perfectly known.

MAN, has been conſidered in a great number of particulars under the title MAN (*Encycl*).; but a reference was made from that article to the article *Varieties of the Human Species*, which was, after all, omitted entirely.

Perhaps enough has been ſaid on the varieties of the human ſpecies in the articles COMPLEXION and NEGRO (*Encycl.*); but as infidel ignorance is perpetually pretending, that the diminutive Icelanders, the ugly Eſquimaux, the woolly-headed Negro, and the copper-coloured American, could not have deſcended from one original pair, either of European complexion or of Hindoo ſymmetry—it may not be improper, in this place, to ſhew the weakneſs of this popular objection to the Moſaic hiſtory of the origin of man. This has been done in ſo ſatisfactory a manner, by Profeſſor Blumenbach, that we ſhall content ourſelves with laying his obſervations before our readers, convinced, as we are, that they are intelligible to every capacity, and that they will carry conviction to all who are not the ſlaves of prejudice.

Phil. Mag. vol. iii. p. 284.

"Some late writers on natural hiſtory (ſays the Profeſſor) ſeem doubtful whether the numerous diſtinct races of men ought to be conſidered as mere varieties, which have ariſen from degeneration, or as ſo many ſpecies altogether different. The cauſe of this ſeems chiefly to be, that they took too narrow a view in their reſearches; ſelected, perhaps, two races the moſt different from each other poſſible, and, overlooking the intermediate races that formed the connecting links between them, compared theſe two together; or, they fixed their attention too much on man, without examining other ſpecies of animals, and comparing their varieties and degeneration with thoſe of the human ſpecies. The firſt fault is, when one, for example, places together a Senegal negro and an European Adonis, and at the ſame time forgets that there is not one of the bodily differences of theſe two beings, whether hair, colour, features, &c. which does not gradually run into the ſame thing of the other, by ſuch a variety of ſhades, that no phyſiologiſt or naturaliſt is able to eſtabliſh a certain boundary between theſe gradations, and conſequently between the extremes themſelves.

"The ſecond fault is, when people reaſon as if man were the only organiſed being in nature, and conſider the varieties in his ſpecies to be ſtrange and problematical, without reflecting that all theſe varieties are not more ſtriking or more uncommon than thoſe with which ſo many thouſands of other ſpecies of organiſed beings degenerate, as it were, before our eyes."

As what we have ſaid under the articles COMPLEXION and NEGRO may be ſufficient to warn mankind againſt the firſt error, and at the ſame time to refute it, we haſten to refute the ſecond by our author's compariſon between the human race and that of ſwine.

"More reaſons (ſays he) than one have induced me to make choice of ſwine for this compariſon; but, in particular, becauſe they have a great ſimilarity, in many reſpects, to man: not, however, in the form of their entrails, as people formerly believed, and therefore ſtudied the anatomy of the human body purpoſely in ſwine; ſo that, even in the laſt century, a celebrated diſpute, which aroſe between the phyſicians of Heidelberg and thoſe of Durlach, reſpecting the poſition of the heart in man, was determined, in conſequence of orders from government, by inſpecting a ſow, to the great triumph of the party which really was in the wrong. Nor is it becauſe in the time of Galen, according to repeated aſſertions, human fleſh was ſaid to have a taſte perfectly ſimilar to that of ſwine; nor becauſe the fat and the tanned hides of both are very like to each other; but becauſe both in regard to the œconomy of their bodily ſtructure, taken on the whole, ſhew unexpectedly, on the firſt view, as well as on cloſer examination, a very ſtriking ſimilitude.

"Both, for example, are domeſtic animals; both *omnivora*; both are diſperſed throughout all the four quarters of the world; and both conſequently are expoſed, in numerous ways, to the principal cauſes of degeneration ariſing from climate, mode of life, nouriſhment, &c.; both, for the ſame reaſon, are ſubject to many diſeaſes, and, what is particularly worthy of remark, to diſeaſes rarely found among other animals than men and ſwine, ſuch as the ſtone in the bladder; or to diſeaſes excluſively peculiar to theſe two, ſuch as the worms found in meaſled ſwine.

"Another reaſon (continues he) why I have made choice of ſwine for the preſent compariſon is, becauſe the degeneration and deſcent from the original race are far more certain in theſe animals, and can be better traced, than in the varieties of other domeſtic animals. For no naturaliſt, I believe, has carried his ſcepticiſm ſo far as to doubt the deſcent of the domeſtic ſwine from the wild boar; which is ſo much the more evident, as it is well known that wild pigs, when caught, may be eaſily rendered as tame and familiar as domeſtic ſwine: and the contrary alſo is the caſe; for if the latter by any accident get into the woods, they as readily become wild again; ſo that there are inſtances of ſuch animals being ſhot for wild ſwine; and it has not been till they were opened, and found caſtrated, that people were led to a diſcovery of their origin, and how, and at what time, they ran away. It is well aſcertained, that, before the diſcovery of America by the Spaniards, ſwine were unknown in that quarter of the world, and that they were afterwards carried thither from Europe. All the varieties, therefore, through which this animal has ſince degenerated, belong, with the original European race, to one and the ſame ſpecies; and ſince no bodily difference is found in the human race, as will preſently appear, either in regard to ſtature, colour, the form of the cranium, &c. which is not obſerved in the ſame proportion among the ſwine race, while no one, on that account, ever doubts that all theſe different kinds are merely varieties that have ariſen from degeneration through the influence of climate, &c. this compariſon, it is to be hoped, will ſilence thoſe ſceptics who have thought proper, on account of theſe varieties in the human race, to admit more than one ſpecies.

"With regard to ſtature, the Patagonians, as is well known, have afforded the greateſt employment to anthropologiſts.

thropologists. The romantic tales, however, of the old travellers who give to these inhabitants of the southern extremity of America a stature of ten feet and more, are scarcely worth notice; and even the more modest relations of later English navigators, who make their height from six to seven feet, have been doubted by other travellers, who, on the same coast, sought for such children of Enoch in vain. But we shall admit every thing said of the extraordinary size of these Patagonians by Byron, Wallis, and Carteret; the first of whom assigns to their chief, and severals of his attendants, a height of not less than seven feet, as far as could be determined by the eye; the second, who asserts that he actually measured them, gives to the greater part of them from 5 feet 10 inches to 6 feet; to some 6 feet 5 inches, and 6 feet 6; but to the tallest, 6 feet 7 inches: and this account is confirmed by the last-mentioned of the above circumnavigators. Now, allowing this to be the case, it is not near such an excess of stature as that observed in many parts of America among the swine, originally carried thither from Europe; and of these I shall mention in particular those of Cuba, which are more than double the size of the original stock in Europe.

"The natives of Guinea, Madagascar, New Holland, New Guinea, &c. are black; many American tribes are reddish brown, and the Europeans are white. An equal difference is observed among swine in different countries. In Piedmont, for example, they are black. When I passed (say our author) through that country, during the great fair for swine at Salenge, I did not see a single one of any other colour. In Bavaria, they are reddish brown; in Normandy, they are all white.

"Human hair is, indeed, somewhat different from swine's bristles; yet, in the present point of view, they may be compared with each other. Fair hair is soft, and of a silky texture; black hair is coarser, and among several tribes, such as the Abyssinians, Negroes, and the inhabitants of New Holland, it is woolly, and most so among the Hottentots. In the like manner, among the white swine in Normandy, as I was assured by an incomparable observer, Sulzer of Ronneburg, the hair on the whole body is longer and softer than among other swine; and even the bristles on the back are very little different, but lie flat, and are only longer than the hair on the other parts of the body. They cannot, therefore, be employed by the brush-makers. The difference between the hair of the wild boar and the domestic swine, particularly in regard to the softer part between the strong bristles, is, as is well known, still greater.

"The whole difference between the cranium of a Negro and that of an European, is not in the least degree greater than that equally striking difference which exists between the cranium of the wild boar and that of the domestic swine. Those who have not observed this in the animals themselves, need only to cast their eye on the figure which Daubenton has given of both.

"I shall pass over (says our author) less national varieties which may be found among swine as well as among men, and only mention, that I have been assured by Mr Sulzer, that the peculiarity of having the bone of the leg remarkably long, as is the case among the Hindoos, has been remarked with regard to the swine in Normandy. 'They stand very long on their hind legs (says he, in one of his letters); their back, therefore, is highest at the rump, forming a kind of inclined plane; and the head proceeds in the same direction, so that the snout is not far from the ground.' I shall here add, that the swine, in some countries, have degenerated into races which in singularity far exceed every thing that has been found strange in bodily variety among the human race. Swine with solid hoofs were known to the ancients, and large herds of them are found in Hungary, Sweden, &c. In the like manner, the European swine, first carried by the Spaniards, in 1509, to the island of Cuba, at that time celebrated for its pearl fishery, degenerated into a monstrous race, with hoofs which were half a span in length."

From these facts our author concludes, that it is absurd to allow the vast variety of swine to have descended from one original pair, and to contend that the varieties of men are so many distinct species.

MANDING, a large state in the interior of Africa, of which the only satisfactory account that we have is by Mr Park, who, for several months, was hospitably entertained in Kamalia, one of its towns, situated in 12° 40′ N. Lat. and 6° 40′ W. Long. The government of Manding appeared to our author to be a sort of republic, or rather an oligarchy. Every town is indeed governed by a chief magistrate called Mansa, which usually signifies king; but the chief power of the state, in the last resort, is lodged in the assembly of these mansas (A). The case, however, is different in other countries, which are occupied by people who have emigrated from Manding; for in all the Mandingo states near the Gambia, the government is monarchical, tho' the power of the sovereign is by no means unlimited.

As Mr Park's route was confined to a tract of country, bounded nearly by the 12th and 15th parallels of latitude, the climate throughout the whole was nearly the same as that of Manding, and extremely hot: Yet, where the country ascended into hills, he found it comparatively cool and pleasant; though none of the districts which he traversed could be called mountainous. About the middle of June, the hot and sultry atmosphere is agitated by violent gusts of wind (called *tornadoes*), accompanied with thunder and rain. These usher in what is denominated *the rainy season*; which continues until the month of November. During this time, the diurnal rains are very heavy; and the prevailing winds are from the south-west. The termination of the rainy season is likewise attended with violent tornadoes; after which the wind shifts to the north-east, and continues to blow from that quarter during the rest of the year.

When

(A) Mr Park, for the most part, writes with remarkable perspicuity; but we are not sure that here we have not mistaken his meaning. He says, that the chief power of the state is lodged in the assembly of that *whole body*; but we think, that by the whole body must be meant the body of *Mansas*, otherwise the government could not be called an oligarchy.

Manding.

When the wind fets in from the north-eaft, it produces a wonderful change in the face of the country. The grafs foon becomes dry and withered; the rivers fubfide very rapidily, and many of the trees fhed their leaves. About this period is commonly felt the *harmattan*, a dry and parching wind, blowing from the north eaft, and accompanied by a thick fmoky haze; through which the fun appears of a dull red colour. This wind, in paffing over the great defert of Sahara, acquires a very ftrong attraction for humidity, and parches up every thing expofed to its current. It is, however, reckoned very falutary, particularly to Europeans, who generally recover their health during its continuance. The truth of this our author experienced both at Kamalia and Pifania, when he had been brought to the very brink of the grave by ficknefs.

Whenever the grafs is fufficiently dry, the negroes fet it on fire; but in Ludamar, and other Moorifh countries, this practice is not allowed; for it is upon the withered ftubble that the Moors feed their cattle until the return of the rains. The burning of the grafs in Manding exhibits a fcene of terrific grandeur. "In the middle of the night (fays Mr Park), I could fee the plains and mountains, as far as my eye could reach, variegated with lines of fire; and the light reflected on the fky made the heavens appear in a blaze. In the day time, pillars of fmoke were feen in every direction; while the birds of prey were obferved hovering round the conflagration, and pouncing down upon the fnakes, lizards, and other reptiles, which attempted to efcape from the flames." This annual burning is foon followed by a frefh and fweet verdure, and the country is thereby rendered more healthful and pleafant.

Though many fpecies of the edible roots, which grow in the Weft India iflands, are found in Africa, yet our traveller never faw, in any part of his journey, either the fugar cane, the coffee, or the cocoa tree; nor could he learn, on inquiry, that they were known to the natives. The pine-apple, and the thoufand other delicious fruits which the induftry of civilized man (improving the bounties of nature), has brought to fo great perfection in the tropical climates of America, are here equally unknown. He obferved, indeed, a few orange and banana trees, near the mouth of the Gambia; but whether they were indigenous, or were formerly planted there by fome of the white traders, he could not pofitively learn.

Concerning property in the foil, it appeared to Mr Park, that the lands in native woods were confidered as belonging to the king, or (where the government was not monarchical) to the ftate. When any individual of free condition had the means of cultivating more land than he actually poffeffed, he applied to the chief man of the diftrict, who allowed him an extenfion of territory, on condition of forfeiture if the lands were not brought into cultivation by a given period. The condition being fulfilled, the foil became vefted in the poffeffor; and, for aught that appeared, defcended to his heirs.

The Mandingoes are a very gentle race of people; cheerful in their difpofitions, inquifitive, credulous, fimple, and fond of flattery. The men are commonly above the middle fize, well fhaped, ftrong, and capable of enduring great labour; the women are good-natured, fprightly, and agreeable. The drefs of both fexes is compofed of cotton cloth of their own manufacture; that of the men is a loofe frock, not unlike a furplice, with drawers which reach half way down the leg; and they wear fandals on their feet, and white cotton caps on their heads. The womens drefs confifts of two pieces of cloth, each of which is about fix feet long and three broad; one of thefe they wrap round the waift, which, hanging down to the ancles, anfwers the purpofe of a petticoat; the other is thrown negligently over the bofom and fhoulders. Both men and women among the Mandingoes feem to have an invincible propenfity to commit depredations on the property of unprotected ftrangers; whilft fuch is the good nature of thofe poor heathens, that they will readily fympathife in the fufferings, relieve the diftreffes, and contribute to the perfonal fafety, of the very ftrangers whom they are bent upon plundering.

Among the Mandingoes, the parental and filial affection is remarkably ftrong between the mother and her child; but not fo between the father and his children. This, as Mr Park obferves, is eafily accounted for. The fyftem of polygamy, while it weakens the father's attachment, by dividing it among the children of different wives, concentrates all the mother's jealous tendernefs to one point, the protection of her own offspring. He perceived, with great fatisfaction too, that the maternal folicitude extended, not only to the growth and fecurity of the perfon, but alfo, in a certain degree, to the improvement of the mind of the infant; for one of the firft leffons, in which the Mandingo women inftruct their children, is *the practice of truth*.

The Mandingo women fuckle their children until they are able to walk of themfelves. Three years nurfing is not uncommon; and during this period, the hufband devotes his whole attention to his other wives. To this practice it is owing, that the family of each wife is feldom very numerous. Few women have more than five or fix children. As foon as an infant is able to walk, it is permitted to run about with great freedom. The mother is not over folicitous to preferve it from flight falls, and other trifling accidents. A little practice foon enables a child to take care of itfelf, and experience acts the part of a nurfe. As they advance in life, the girls are taught to fpin cotton, and to beat corn, and are inftructed in other domeftic duties; and the boys are employed in the labours of the field. Both fexes, whether Bufhreens or Kafirs, on attaining the age of puberty, are circumcifed. This painful operation is not confidered by the Kafirs fo much in the light of a religious ceremony, as a matter of convenience and utility. They have, indeed, a fuperftitious notion, that it contributes to render the marriage ftate prolific.

When a young man takes a fancy to a young girl, and wifhes to marry her, it is by no means confidered as neceffary that he fhould make an overture to the girl herfelf. The firft object is to agree with the parents, concerning the recompence to be given them for the lofs of the company and fervices of their daughter. The value of two flaves is a common price, unlefs the girl is thought very handfome; in which cafe, the parents will raife their demand very confiderably. If the lover is rich enough, and willing to give the fum demanded, he then communicates his wifhes to the damfel: but her confent consent is by no means necessary to the match; for if the parents agree to it, and eat a few *kolla-nuts*, which are presented by the suitor as an earnest of the bargain, the young lady must either have the man of their choice, or continue unmarried, for she cannot afterwards be given to another. If the parents should attempt it, the lover is then authorised, by the laws of the country, to seize upon the girl as his slave. At the celebration of a marriage, no religious ceremony seems to be practised. A select number of people are indeed invited to the wedding, and feasted; but consummation constitutes the marriage; for towards the morning, the new married couple are always disturbed by the women, who assemble to inspect the nuptial sheet (according to the manners of the ancient Hebrews, as recorded in Scripture), and dance round it. This ceremony is thought indispensably necessary; nor is the marriage considered as valid without it.

The Madingoes, and indeed all the negro states, whether Mahomedan or Pagan, allow a plurality of wives. The consequence is, that the wives frequently quarrel among themselves. When this happens, the husband decides between them; and sometimes finds it necessary to administer a little corporal chastisement before tranquillity can be restored. But if any one of the ladies complains to the chief of the town, that her husband has unjustly punished her, and shewn an undue partiality to some other of his wives, the affair is brought to a public trial. In these *palavers*, however, which are conducted chiefly by married men, our author was informed, that the complaint of the wife is not always considered in a very serious light; and the complainant herself is sometimes convicted of strife and contention, and left without remedy. If she murmurs at the decision of the court, the magic rod of *Mumbo Jumbo* soon puts an end to the business. See Mumbo Jumbo in this *Suppl.*

A child, among them, is named when it is seven or eight days old. The ceremony commences by shaving the infant's head; and a dish called *dega*, made of pounded corn and sour milk, is prepared for the guests. If the parents are rich, a sheep or a goat is commonly added. This feast is called *ding koon lee*, "the child's head shaving." During Mr Park's stay at Kamalia, he was present at four different feasts of this kind, and the ceremony was the same in each, whether the child belonged to a Bushreen or a Kafir. The schoolmaster, who officiated as priest on those occasions, and who is necessarily a Bushreen, first said a long prayer over the *dega*; during which, every person present took hold of the brim of the calabash with his right hand. After this, the schoolmaster took the child in his arms, and said a second prayer: in which he repeatedly solicited the blessing of God upon the child, and upon all the company. When this prayer was ended, he whispered a few sentences in the child's ear, and spit three times in its face; after which he pronounced its name aloud, and returned the infant to the mother. This part of the ceremony being ended, the father of the child divided the *dega* into a number of balls, one of which he distributed to every person present. And inquiry was then made, if any person in the town was dangerously sick; it being usual, in such cases, to send the party a large portion of the *dega*, which is thought to possess great medical virtues.

The Madingoes have no artificial method of dividing time. They calculate the years by the number of *rainy seasons*. They portion the year into *moons*, and reckon the days by so many *suns*. The day they divide into morning, mid-day, and evening; and further subdivide it, when necessary, by pointing to the sun's place in the heavens. Our author frequently inquired of some of them, what became of the sun during the night, and whether we should see the same sun, or a different one in the morning? But that subject appeared to them as placed beyond the reach of human investigation; they had never indulged a conjecture, nor formed any hypothesis, about the matter. The moon, by varying her form, has more attracted their attention. On the first appearance of the new moon, which they look upon to be newly created, the Pagan natives, as well as Mahomedans, say a short prayer; and this seems to be the only visible adoration which the Kafirs offer up to the Supreme Being. This prayer is pronounced in a whisper; the party holding up his hands before his face: its purport is to return thanks to God for his kindness through the existence of the past moon, and to solicit a continuation of his favour during that of the new one. At the conclusion, they spit upon their hands and rub them over their faces. Great attention is paid to the changes of this luminary in its monthly course; and it is thought very unlucky to begin a journey, or any other work of consequence, in the last quarter. An eclipse, whether of the sun or moon, is supposed to be effected by witchcraft. The stars are very little regarded; and the whole study of astronomy appears to them as a useless pursuit, and attended to by such persons only as deal in magic.

Their notions of geography are equally puerile. They imagine that the world is an extended plain, the termination of which no eye has discovered; it being, they say, overhung with clouds and darkness. They describe the sea as a large river of salt water, on the farther shore of which is situated a country called *Tobaubo doo*; "the land of the white people." At a distance from Tobaubo doo, they describe another country, which they allege is inhabited by cannibals of gigantic size, called *Koomi*.

Mr Park says he has conversed with all ranks and conditions of negroes on the subject of their faith, and that he can pronounce, without the smallest shadow of doubt, that the belief of one God, and of a future state of reward and punishment, is entire and universal among them. It is remarkable, however, that, except on the appearance of a new moon, as before related, the Pagan natives do not think it necessary to offer up prayers and supplications to the Almighty. They represent the Deity, indeed, as the creator and preserver of all things; but in general they consider him as a Being so remote, and of so exalted a nature, that it is idle to imagine the feeble supplications of wretched mortals can reverse the decrees, and change the purposes, of unerring wisdom. The concerns of this world, they believe, are committed by the Almighty to the superintendance and direction of subordinate spirits, over whom they suppose that certain magical ceremonies have great influence. A white fowl, suspended to the branch of a particular tree, a snake's head, or a few handfuls of fruit, are offerings which ignorance and superstition frequently present, to deprecate

deprecate the wrath, or to conciliate the favour, of these tutelary agents.

The Mandingoes seldom attain extreme old age. At forty, most of them become grey haired, and covered with wrinkles; and but few of them survive the age of fifty-five, or sixty. Yet their diseases appeared but few; fevers and fluxes being the most common, and the most fatal. For these they generally apply *saphies*, i. e. charms, to different parts of the body; though sometimes, on the first attack of a fever, the patient is, with great success, placed in a sort of vapour bath. The other diseases which prevail among the negroes, are the *yaws*, the *elephantiasis*, and a *leprosy* of the very worst kind, together with the *Guinea worm*, which they attribute to bad water.

When a person of consequence dies, the relations and neighbours meet together, and manifest their sorrow by loud and dismal howlings. A bullock or goat is killed for such persons as come to assist at the funeral; which generally takes place in the evening of the same day on which the party died. The negroes have no appropriate burial places, and frequently dig the grave in the floor of the deceased's hut, or in the shade of a favourite tree. The body is dressed in white cotton, and wrapped up in a mat. It is carried to the grave, in the dusk of the evening, by the relations. If the grave is without the walls of the town, a number of prickly bushes are laid upon it, to prevent the wolves from digging up the body; but our author never observed that any stone was placed over the grave as a monument or memorial.

With respect to employment, the men cultivate the ground, or catch fish in large rivers; while the women manufacture cotton cloth. It is only the spinning and the dyeing, however, that are performed by the women; for the web, which is seldom more than four inches broad, is wove by the men in a loom made exactly upon the same principle as that of Europe. As the arts of weaving, dyeing, sewing, &c. may easily be acquired, those who exercise them are not considered in Africa as following any particular profession; for almost every slave can weave, and every boy can sew. The only artists which are distinctly acknowledged as such by the negroes, and who value themselves on exercising appropriate and peculiar trades, are the manufacturers of leather and of iron. The first of these are called *Karrankea* (or as the word is sometimes pronounced *Gaungay*). They are to be found in almost every town, and they frequently travel through the country in the exercise of their calling. They tan and dress leather with very great expedition, by steeping the hide first in a mixture of wood-ashes and water, until it parts with the hair; and afterwards by using the pounded leaves of a tree, called *goo*, as an astringent.

The manufacturers in iron are not so numerous as the *Karrankeas*; but they appear to have studied their business with equal diligence. The negroes on the coast being cheaply supplied with iron from the European traders, never attempt the manufacturing of this article themselves; but in the inland parts, the natives smelt this useful metal in such quantities, as not only to supply themselves from it with all necessary weapons and instruments, but even to make it an article of commerce with some of the neighbouring states. During our author's stay at Kamalia, there was a smelting furnace at a short distance from the hut where he lodged, and the owner and his workmen made no secret about the manner of conducting the operation; and readily allowed him to examine the furnace, and assist them in breaking the iron-stone. The process it is needless to describe; though it be proper to observe, that the mass of metal obtained by it was rather steel than iron. Most of the African blacksmiths are acquainted also with the method of smelting gold, in which process they use an alkaline salt, obtained from a ley of burnt corn-stalks evaporated to dryness. They likewise draw the gold into wire, and form it into a variety of ornaments, some of which are executed with a great deal of taste and ingenuity.

The reader will observe, that in the extracts which we have made from Mr Park's interesting travels, the terms African and Negro are frequently used as if all Africans and Negroes were Mandingoes. The reason is, that the Mandingoes were not only the most numerous tribe which he visited, but were also spread over all that tract of country which he traversed.

MANOMETER, a small glass tube two or three inches high, hermetically sealed at one end, and open at the other, and divided regularly into inches and lines. It is employed in order to ascertain the rarefaction of the air produced by working an *air-pump*. The tube previously filled with mercury, and having its open end plunged into a bason of mercury, is placed in the receiver of an air-pump. As the piston is worked, the mercury gradually sinks in the tube, and the expansion is estimated by its height; for the smaller the height at which the mercury in the tube stands above the mercury in the bason, the greater is the expansion.

MANIANA, a small negro kingdom lying between 12° and 14° North Lat. and between the meridian of Greenwich and 1° and 30′ West Long. Its inhabitants, as Mr Park was informed by a variety of people in many different kingdoms, are remarkable for cruelty and ferocity; carrying their resentment to their enemies so far as never to give quarter, and even indulging themselves with banquets of human flesh. Hence the inhabitants of Bambarra, who carried on with them a long and bloody war, and must of course be well ascertained of the fact, call them *Ma dummulo*, which signifies men-eaters.

MANURE is so essential to agriculture, that the want of it, or an improper manner of using it, is the principal cause of the sterility of a country. We have therefore treated of manures and their action at some length in the article AGRICULTURE in the *Encyclopædia*; but as the theoretical part of that disquisition rests in a great measure on the doctrine of phlogiston, which is now exploded, it may not be improper to resume the subject here. Experience however being, after all, the only guide which the farmer can safely and confidently follow, instead of amusing our readers with theories of our own, we shall lay before them the observations of a man who seems to have united theory with practice.

"The use of manures (says M. Parmentier *) has been known in all ages, but we are yet far from having any clear and precise ideas of the nature of the juices which are destined for the nourishment of vegetables, and of the manner in which they are transmitted to their organs.

* Memoirs of the Royal Society of Agriculture, Paris.

Manure. organs. The writers on agriculture, who have endeavoured to explain thefe matters, perceiving falts in moft plants, were perfuaded that thefe falts, by the help of water and heat, paffed, in a faline form, through the vegetable filter. Thefe firft philofophers did not hefitate to confider every thing that has been done by the induftry of man, to improve the nature of land, and its productions, as merely forming refervoirs of thefe falts, which they confidered as the principle of fertility. This opinion was fo well eftablifhed among the improvers of land, that, to this day, many of them have no object in view, in their operations, but to difengage falts; and, when they attempt to explain certain phenomena which take place in their fields or orchards, they talk confidently about the *nitre of the air*, *of rain*, *of fnow*, *of dew*, *and fogs*; of the *falts of the earth*, *of dung*, *of marle*, *of lime*, *of chalk*, &c. and make ufe of thofe vague terms, *oil*, *fulphur*, *fpirit*, &c. which ought henceforward to be banifhed from our elementary books on agriculture.

" Among the authors who have attacked, and combated with moft fuccefs, the opinion that the fruitfulnefs of foils, and the aliment of vegetables, refide in faline fubftances, muft be reckoned Eller and Wallerius. Thefe philofophers examined, by every means which chemiftry at that time could furnifh, the various kinds of earth proper for cultivation, and alfo thofe fubftances which have always been confidered as the moft powerful manures, without being able to obtain, from any of them, any thing more than mere atoms of falt.

" Animated with the fame zeal, and taking advantage of the inftructions found in their writings, I thought it neceffary to determine, by experience, whether, as has been afferted, there really exift neutral falts in earths; and alfo, whether thofe earths are more fertile in proportion to the quantity of fuch falts they contain. With this view, I lixiviated, by means of diftilled water, many fpecies of cultivated earths, taken in various ftates, from frefh earth to that which had been impoverifhed by the growth of feveral crops; I alfo tried dung, reduced more or lefs into the ftate of mould; and likewife the moft active manures, fuch as the offal of animal fubftances rotted by putrefaction; but in none of thefe, however carefully analyzed, were found any falts in a free ftate. They contain indeed the materials proper for forming falts; but if they contain any ready formed, it is merely by accident.

" The refearches of Kraft, and thofe of Alfton, were not attended with different refults. Having fown fome oats in afhes, not lixiviated, and in fand ftrongly impregnated with potafh and with faltpetre, and having found that the oats did not grow, they concluded that neutral falts, and alkalies, not only retarded the growth of vegetables, but that they abfolutely prevented it. It is well known that in Egypt there are diftricts where the earth is entirely covered with fea-falt, and thefe diftricts are quite barren. It is probably owing to this property of fea-falt, that the Romans were accuftomed to fcatter large quantities of it over fields where any great crime had been committed, and of which they wifhed to perpetuate the remembrance, by rendering the part barren for a certain time.

" The idea that falts had great influence in vegetation, ought to have been greatly weakened by the following fimple reflection. Suppofing that falts exifted in garden mould, they would be very foon diffolved by the rain, and carried away, towards the lower ftrata of the earth, to a depth to which the longeft roots would not reach. Indeed the famous experiment of Vanhelmont would have been fufficient to have deftroyed the above opinion, if it did not generally happen that we are no fooner fet free from one error than we fall into another not lefs extraordinary. The furprifing effects of vegetation brought about by the overflowing of water, and in the neighbourhood of falt marfhes, and the infinite number of inhaling capillary tubes obferved upon the furface of vegetables, led to an opinion that the air and water, abforbed by the roots and leaves of plants, were only vehicles loaded with faline matter, analogous to the vegetables nourifhed by them.

" To the experiment of Vanhelmont, which was repeated by many accurate obfervers, fucceeded thofe of modern philofophers; from which it clearly appeared, that plants could grow, and produce fruit, in the air of the atmofphere, and in diftilled water, alfo in pure fand, in powdered glafs, in wet mofs or fponge, in the cavity of flefhy roots, &c. and that plants which had nothing but the above-mentioned fluids for their nourifhment, gave, when fubmitted to chemical analyfis, the fame products as thofe which had undergone their procefs of vegetation in a foil perfectly well manured. It was alfo obferved, that the moft barren foils were rendered fertile when they were properly fupplied with water by canals; and the efficacy of irrigation was repeatedly evinced in different ways: from thefe obfervations was formed the following fyftem, that water rifes in plants in the form of vapour, as in diftillation; that air introduces itfelf into their pores; and that, if falts contribute to the fruitfulnefs of foils, it is only in confequence of their containing the two fluids above-mentioned in great abundance."

Our author, after making many experiments upon various foils and falts, and after attending minutely to the procefs of vegetation, thinks himfelf warranted to maintain, " that faline fubftances have no fenfible effects in promoting vegetation, excepting inafmuch as they are of a deliquefcent nature, have an earthy bafis eafily decompofed, and are ufed only in fmall quantity. In thofe circumftances they have the power of attracting, from the immenfe refervoir of the atmofphere, the vapours which circulate in it; thefe vapours they retain, along with the moifture that is produced from rain, fnow, dew, fog, &c. which moifture they prevent from running together in a mafs, or from being loft, either by exhaling into the air of the atmofphere, or by filtering itfelf through the inferior ftrata of the earth, and thereby leaving the roots of vegetables dry; they diftribute that moifture uniformly, and tranfmit it, in a ftate of great divifion, to the orifices of the tubes deftined to carry it into the texture of the plant, where it is afterwards to undergo the laws of affimilation. As every kind of vegetable manure poffeffes a vifcous kind of moifture, it thereby partakes of the property of deliquefcent falts. In fhort, the preparation of land for vegetation has no other object in view but to divide the earthy particles, to foften them, and to give them a form capable of producing the above-mentioned effects. It is fufficient, therefore, that water, by its mixture with

Manure. with the earth and the manure, be divided, and ſpread out ſo as to be applied only by its ſurface, and that it keep the root of the plant always wet, without drowning it, in order to become the eſſential principle of vegetation. But as plants which grow in the ſhade, even in the beſt ſoil, are weakly, and as the greater part of thoſe which are made to grow in a place that is perfectly dark neither give fruit nor flowers, it cannot be denied that the influence of the ſun is of great importance in vegetable economy."

Such was the opinion which our author gave of the manner in which ſalts act in vegetation, at a time when it was not known that air and water (which had been ſo long conſidered as elements), far from being ſimple ſubſtances, are capable of being decompoſed by a great variety of operations both of nature and art; and nothing was wanting to complete his theory, but to know that air and water act their part in vegetation only in a ſtate of decompoſition; and that if earth well manured is a better matrix than water itſelf, it is becauſe ſuch earth has the power of converting the water into gaſes which are eaſily abſorbed, and which, while their abſorption takes place, communicate to the plants a motion and heat which they received when taking the form of gas, and which they loſe when they enter again into combination; whence it is natural to conclude, that this motion and this heat muſt neceſſarily develope themſelves in ſeeds, and maintain the vital action in plants.

What is a vegetable, conſidered chemically, according to the preſent ſtate of our knowledge? It is, ſay the chemiſts, a compound of hydrogen, oxygen, and carbon, the proportions of which vary according to the agents which have concurred to its developement, and according to the matrix which received and aſſimilated them, in order to create thoſe combinations which are varied to infinity, by their forms and properties, and known by the generic terms of ſalt, oil, and mucilage. It appears, therefore, needleſs to ſeek theſe combinations in the different ſubſtances which are uſed for manure, when we wiſh to determine the nature of them, and explain their manner of acting in vegetation; becauſe, ſuppoſing it true that theſe ſalts, theſe oils, or theſe mucilages, exiſt in their combined ſtate, nothing but their conſtituent elements, namely, hydrogen, oxygen, and carbon, can poſſibly have any action.

The ſuperiority of animal ſubſtances, as manures, and the remarkable luxuriance of thoſe plants which are watered with putrid water, prove inconteſtibly, that the putrid ſtate is favourable to vegetation, and that every ſubſtance which is liable to enter, to a certain degree, into that ſtate, contributes very powerfully thereto. The moſt aerated waters are, in this caſe, the moſt beneficial. It is obſerved that rain, particularly in ſtormy weather, quickens vegetation ſo much, that the gardeners in the neighbourhood of Paris are often obliged to drench their plants with water taken from their wells, which, in conſequence of its rawneſs, or its want of air, retards the vegetation of the plants; either becauſe it precipitates the meteoriſed or electrified water, or becauſe, by being mixed with the other water, it diminiſhes its fertilizing quality; whereas, in ſummer, this ſame well-water, by being expoſed to the ſun for ſome days, acquires a ſmell like that of ſtale eggs, loſes its rawneſs, and becomes very fit for accelerating vegetation. An atom of vegetable or animal matter is, at that time, ſufficient to bring about more quickly this ſtate of putrefaction; while theſe ſame ſubſtances, by being employed in certain proportions, far from acting as a leaven on the liquids which hold them in ſolution, preſerve thoſe liquids, or at leaſt make them more ſlow to change. Manure.

Salts and dung, therefore, are not merely decompoſed by the power of vegetation; by furniſhing the reſults of their decompoſition, they alſo act in the manner of leavens, the action of which is ſcarcely perceptible in cold or dry weather; but when they are heated by the ſun, and ſufficiently penetrated with moiſture, they very ſoon enter into a ſort of fermentation, ſuffering the various gaſes with which they are provided to eſcape. Thus manures may be conſidered as decompoſing inſtruments, provided by nature, and prepared by art, to act upon water ſo as to bring it to a proper ſtate of attenuation. The ſubſtances which enter into the compoſition of plants, are, therefore, nothing but products of the decompoſition of air and water, and combinations of the conſtituent principles of theſe two fluids, determined by the power which preſides in the ſeed, and which thence has paſſed into the plant.

It is now eaſy to account for the effects of charcoal-powder, ſtraw, &c. which are made uſe of to cover ground during long droughts with undoubted benefit: they are mechanical means of preventing the diſſipation of moiſture, and of determining it to take the form of thoſe gaſeous fluids which have ſuch powerful effect in vegetation. As water is compoſed of hydrogen and oxygen, it is not ſurpriſing that, when aſſiſted by the influence of the ſun, and that of electricity, it is capable of forming, almoſt by itſelf, the ſolids and fluids of vegetables; taking from the atmoſphere the carbon it ſtands in need of, to give them their moſt eſſential characters. We ſay their moſt eſſential characters; for thoſe terreſtrial plants which have grown in air and water do not abound in principles; and their offspring, when they have any, is by no means vigorous. We ſee alſo, that plants which are naturally of an equatic nature, have in general but little ſmell, becauſe the medium in which they live and grow furniſhes only a ſmall quantity of carbon, in proportion to the hydrogen and oxygen, which are the conſtituent principles of water. This is the reaſon why, in cold and wet years, flowers are leſs odoriferous, fruit leſs full of flavour, and more difficult to be preſerved. The germ of their reproduction is weak; and they are, if the expreſſion may be uſed, in a ſort of dropſy; that is to ſay, they are loaded with the principles which conſtitute water, and even with water itſelf.

Theſe obſervations, to which more might be added, may ſerve to explain why vegetation is ſlow and weak in a ſoil which is too much charged with ſaline matter, while it is rendered quick and vigorous by a ſmall quantity of this ſame matter; and why earth, which is perfectly lixiviated, and watered, from time to time, with diſtilled water only, is capable of giving to bitter plants their bitterneſs, to ſweet ones their ſweetneſs, to acid ones their acidity, to aromatic ones their ſpicineſs, and to poiſonous ones their deleterious qualities; in ſhort, why the inherent characters of plants are more ſtrongly marked, in proportion as the ſoil in which they grow is furniſhed with natural or mechanical means to produce

Manure. duce a quantity of gas neceffary to the formation of the fubftances on which thofe characters depend.

If a nitrous or marine plant can, even when growing in a foil deftitute of nitre or fea-falt, occafion the production of thefe falts, it muft be allowed that fuch plants would vegetate more ftrongly, and contain more of fuch falts, if they grew in foils more abounding in materials proper to form them. Thus, the different fpecies of famphire, glaffwort, fea-wrack, &c. flourifh on the borders of the fea, fuch foils being ftrongly impregnated with the fluids neceffary to form the muriatic gas and fea-falt which enter into the compofition of thofe plants, while the fun-flower, pellitory, &c. fucceed beft in earth which is mixed with the ruins of old buildings, in which the materials for the production of nitrous gas, and even of nitre itfelf, are very abundant. In fhort, the organization of thefe plants is a real elaboratory for forming the forementioned falts.

Thofe plants which, for their vegetation, require the moft affiftance from the foil and manure, are very apt to contract a difagreeable tafte, if either the foil or manure are capable of fupplying the principles from which it is acquired. The clafs *tetradynamia*, particularly all forts of cabbages (which contain fulphur ready formed), contract a bad tafte in a foil compofed of mud and dung, becaufe thefe fubftances, as they are decompofed, furnifh a great quantity of hepatic gas, or of fulphurifed hydrogen gas; yet plants of another clafs may grow in the fame foil, clofe by the cabbages, without partaking even in the fmalleft degree of the bad tafte of the latter. The plants laft mentioned, when growing in hepatic gas, retain only fo much of it as is fufficient for the production of the fubftances of which they are formed; the overplus, which could not be affimilated, is thrown out by the excretory veffels, after undergoing thofe modifications which the digeftive juices and organization of the plant, and the ftate of the atmofphere, have produced.

Thus we fee that thofe plants which abound moft in oily, faline, and mucilaginous principles, are generally fuch as require a foil well manured. Tobacco, for inftance, gives forty pounds of alkaline falt or potafh from every hundred weight of afhes: this plant may, by being buried in the ground, be converted into a very powerful manure; while other plants, which thrive in a middling foil, and appear as vigorous, are, in general, fuch as have not fo great a quantity of principles in their compofition, and when thrown on the dunghill, and left to rot, furnifh very little manure. From fuch obfervations, it may perhaps not be impoffible hereafter to judge, by the analyfis of a plant, not only whether it requires a large or a fmall quantity of manure, but likewife what kinds of foil and manure are moft fit to promote its vegetation: wild plants alfo may ferve to fhew the nature of the foil which they feem moft to flourifh in.

Befides the phyfical action of manures, they have a very evident mechanical action. When mixed with earth, in a certain proportion, they not only render it more permeable to water, but the roots of plants can with greater eafe acquire their proper fize and form in it: in other cafes, manures tend to unite that earth which is too loofe, and, by rendering it more tenacious, they prevent the water from being loft, and the roots from becoming dry. Thofe manures which are called *warm* are fuited to cold lands, not only becaufe they render them lefs compact, but alfo becaufe they take off a part of that moifture which fuch lands always have in too great quantity. Cold manures, on the other hand, by their vifcid quality, give tenacity to dry and hot foils, attracting and retaining, for a longer time, the moifture which comes in their way. The nature of the foil muft therefore determine what kind of manure it ftands in need of, and alfo whether cultivating it by means of oxen or by horfes is preferable; for the manures produced from thefe two animals have thofe oppofite qualities which we have above defcribed. By fuch obfervations, we fhall perhaps be able to refolve a queftion, refpecting which the fentiments of cultivators in many parts of the kingdom are much divided.

It cannot, however, be denied, that the earth is able of itfelf to ferve as a bafis and fupport to plants, and that it has an action more or lefs evident upon air, upon water, and upon dung. There is a well-known method of diftinguifhing clay from other earths; by merely breathing upon it, a fmell is immediately perceived, fufficiently ftrong to fhew that a decompofition and frefh combination have taken place. In fummer, after a drought of fome days continuance, there always arifes in the fields a particular fmell during a fhower of rain; and there is no kind of vegetable manure which, when mixed with earth, does not fend forth a fmell. This proves, that the nature of the foil muft have an influence, not only upon air and upon water, but alfo upon the effect of manures; and that before we fpeak of their power, we fhould always fpecify what kind of earth they were applied to; becaufe when manures and earth are mixed together, there enfues an action and reaction more or lefs favourable to vegetation.

Having examined to what degree air and water enter, in fubftance, into the veffels of plants, and having fhewn that the principal action of earth, of falts, and of manures, confifts in preparing, elaborating, and decompofing thefe two fluids, and in giving to the products of their decompofition the forms they require, to accomplifh the purpofe of nature in vegetation, our author makes fome obfervations upon the particular effects of certain fubftances ufed for improving land, fuch as marl, lime, chalk, and wood-afhes; which are ufually applied either to an exhaufted foil, in order to reftore it, or to a drooping plant, with a view to give it ftrength. Of the efficacy of thefe fubftances no one doubts, but it does not appear that we are equally agreed refpecting their manner of acting.

Marl (a manure whofe effects are well known, and which is found to be of the greateft benefit in thofe diftricts where it can be procured in fufficient quantity) is capable of acting in the fame manner as the moft fertile foil, when the principles of which it is compofed, namely, clay, fand, calcareous earth, and magnefian earth, are juftly proportioned to each other. But it is fometimes compact and tenacious, becaufe it contains a fuperabundant portion of clay, and at other times porous and friable, becaufe it contains too much fand, and therefore is not in general fit for vegetation by itfelf. Thefe confiderations ought always to be our guide when we mean to employ marl as a manure.

It has been fuppofed that *to marl* was a fort of technical expreffion, intended to denote the bringing together

Manure. ther or dividing the earthy particles by means of clay or fand. It appears to our author, that neither of the above operations can properly be called *marling*; becaufe, in either cafe, all we do is, to put the foil into a fituation to receive and to profit by the influence of the atmofphere, and that of the manures made ufe of. The peculiar principle of marl is, that part of it which, like lime, acts very powerfully upon the different aeriform fluids, is eafily reduced to powder, effervefces with acids, and fends forth a quantity of air-bubbles when water is poured upon it. Now this matter, which in a particular manner does the office of manure, refides neither in clay nor in fand. Upon the proportion of it depends the duration of the fertility it produces; confequently it is of importance, when we make ufe of marl, to know which of its conftituent parts it contains in the greateft proportion, otherwife in fome cafes we fhould only add one common kind of earth to another. Hence our author infers, that for a chalky foil clay is the proper manure, and that in fuch a foil a clay bottom is of more value than a gold mine.

"Wood-afhes, as a manure, may be, in fome refpects, compared to marl; at leaft they contain the fame earths as thofe which generally enter into the compofition of marl, but they contain a greater quantity of faline fubftances, proceeding from the vegetables of which they are the refidue, and from the procefs made ufe of in their combuftion; a procefs which increafes their activity, and fhould render us careful in what manner and for what purpofes we employ them. Wood-afhes, when fcattered over fields, at proper times and in proper quantities, deftroy weeds, and encourage the vegetation of good plants. But do the afhes produce this effect by a fort of corrofive power? I cannot (fays our author) think it; for in that cafe all kinds of plants would indifcriminately be acted upon by them, and to a certain degree deftroyed.

"Befides, the afhes of frefh wood are feldom employed until they have been lixiviated, in which ftate they are deprived of their cauftic principle; thofe afhes which are moft commonly made ufe of for manure are produced either from wood that has been floated in water, or from turf, or from pit-coal, and contain little or no alkaline falt.

"It appears much more probable that afhes, when laid upon ground, deftroy the weeds by a well-known effect, namely, by feizing with eagernefs that moifture which ferved to produce thofe weeds, and which in a fuperabundant quantity is neceffary to their exiftence and fupport. Whereas thofe plants which have a firmer texture and a longer root, which are rendered ftrong by age and by having withftood the rigour of winter, and which are in fact the plants of which the fields are compofed, do not fuffer any damage from the application of the afhes; but, on the contrary, by being freed from the fuperfluous weeds which ftifled them, and robbed them of a part of their fuftenance, they receive a quantity of nourifhment proportioned to their wants. The ftate of relaxation and langour to which they were reduced by a fuperabundance of water, leaves them, the foil gets its proper confiftence, and the grafs, corn, &c. acquiring the ftrength and vigour which is natural to them, foon overcome the mofs, rufhes, and other weeds; thus a good crop, of whatever the field confifts of, is produced. It is in the above manner that wood-afhes act, whenever in the fpring it is neceffary to apply them to meadows, corn-fields, &c. the plants of which are ftifled and weakened by a luxuriant vegetation of weeds, the ufual confequence of mild and wet winters. Manure.

"When wood-afhes produce an effect different from what is above defcribed, it is either becaufe they happen to contain too much alkaline falt, or that they are laid on the ground in too great quantity, or that the fields to which they are applied were not fufficiently wet to reftrain their action; for when they are fcattered upon cold foils, and buried by the plough before the time of fowing, they are like lime, of great fervice. The laftmentioned fubftance is very efficacious in other circumftances; and there is a well-known method of ufing it, practifed by the Germans, as follows: A heap of lime is formed by the fide of a heap of poor earth, and water is poured upon the lime; the earth is then thrown over it, and becomes impregnated with the vapours which efcape from the lime while it is flaked. The earth, after being thus aerated, may be feparated; and although no lime remains mixed with it, is, by the operation juft defcribed, rendered capable of giving a luxuriant vegetation to whatever plants may be put into it.

"It is poffible, therefore, to aerate earth as well as fluids; for this purpofe, by mixing it with certain fubftances, during their decompofition, we muft attach to it the principles of which thofe fubftances are compofed; from which there refults a matter fo loaded with gas, as to form a more compound fubftance, and one which has acquired new properties. The Arabians, for example, who take great pains to improve their land, are accuftomed to make large pits, which they fill with animals which happen to die: thefe pits they afterwards cover with calcerous or clayey earth; and after fome time thefe earths, which of themfelves are fterile, acquire the properties of the richeft manures.

"The foregoing obfervations may at leaft be confidered as proving, that thofe fubftances which, when employed frefh and in too great quantity, are more prejudicial to vegetation, have, on the contrary, an advantageous effect, when they are previoufly made to undergo a fermentation; or when they are mixed with earth or water, in a proportion adapted to the end propofed. The grafs of fields in which cattle or poultry go to feed, after the firft or fecond crop of hay, appears to be dried by the urine and dung of thofe animals; as if fire had been applied to it; whereas thefe fame excrementitious fubftances, when combined with earth, or diluted with water, are capable, without any other preparation, of performing the office of good manure.

"But if animal fecretions, when applied in fubftance to plants, were capable of acting upon them, as is affirmed, in fuch a way as to corrode or burn them, how could feed which has been fwallowed, and efcaped the action of the digeftive powers, be prolific when thrown out by the animal, after having remained fo long in its dung? yet we often fee oats, fo circumftanced, grow and produce feed. It is not more confiftent with experience and obfervation to fuppofe, that thefe excrementitious fubftances, being ftill endowed with animal heat, and with an organic motion, diffufe round plants in vegetation a deleterious principle or inflammable gas, which deftroys them: for foon after their application, the foliage of the plant grows yellow, dries up, and the plant withers, unlefs there happens a fhower of rain

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Manure.

which revives it. When these substances are diluted, by being mixed with water and earth, they lose that principle which is so destructive to vegetable life, and an incipient fermentation augments their power as a manure, so that they may be immediately made use of without any apprehension of injury from their effects.

"It appears, therefore, that any operation upon excrementitious substances, by which they are dried and reduced to powder, cannot be practised without depriving those substances of a great part of such of their principles as are easily evaporated, and upon which their fluidity depends; these principles, when diluted with water, and confined by being mixed with earth, are capable of increasing the produce of the soil. Such is the way in which the husbandmen in Flanders make use of this kind of manure, in the cultivation of a kind of rape or cole seed, which is to them a very important branch of agricultural industry and commerce; and they never observe that the sap carries up any of those principles which give such manure its offensive smell; nor do they observe, that the fodder produced from fields so manured, whether eaten fresh or dry, is disagreeable to their cattle. The excrements of all animals would be injurious to plants, if applied too fresh, or in too great quantity; and a gardener could not commit a greater fault, than to put more than a certain quantity of them into the water he means to make use of to water his young plants; in short, this kind of manure is to be used in a very sparing manner; and he that is too prodigal of it will find, to his cost, that excess, even of that which is otherwise beneficial, becomes an evil.

"It must certainly be allowed, that excrementitious substances are a very advantageous manure for cold soils, and suited to most vegetable productions; a long experience of their effects over a large tract of country, and the acknowledged intelligence of the Flemish farmers, ought to be considered as sufficient to overcome the prejudice that has been raised against this sort of manure. Supposing that the bad effects which have been attributed to it, when used in the state in which it is taken out of privies, &c. are not the offspring of a prejudiced imagination, they may have arisen from its having been made use of at an improper time, or in too great quantity; or from its having been applied to a soil and for the cultivation of plants to which it was not adapted; for we know that the excess of any kind of manure changes the smell and taste of plants, and the same effect is produced by watering them too frequently. Striking examples of this change are seen in the strawberry and in the violet, when such as have grown in the woods are compared to those produced from some of our over-manured gardens; also in the lettuce, and some other plants, when those raised for sale by the gardeners about Paris are compared to those of some particular kitchen gardens. In the markets of some cities, the carrots, turnips, and potatoes of the fields, are preferred to the same kind of roots cultivated by the gardeners (A); for though the last are of a larger size, they have not got so good a flavour. Some vegetables, therefore, are like certain wild species of the animal kingdom; they resist every kind of culture, as those animals resist every effort to tame them.

"Although experience has taught the Flemish farmers, that excrementitious substances are more active in their natural state than when dried, yet it cannot be denied that drying them, and reducing them into powder, is sometimes very advantageous; because in that state they are much less offensive, are easily transported to any distance, and may be used when most convenient or most proper. In many cities the inhabitants pay to have their privies emptied: in other places, those who empty them pay for their contents; and it would astonish any one to be told how great a revenue is produced in the city of Lisle in Flanders by the sale of this kind of manure. I am, however (says our author), far from thinking that it is right, in all cases, to employ it in the above-mentioned state of concentration; it would be better, in my opinion, to follow the example of the Flemish farmers, who use it the first year for the cultivation of plants for oil, or for hemp or flax; and the second year for the best kinds of grain: thus obtaining two crops, instead of one, without any farther preparation of the land. What is said above may be applied also to the manures produced from the dung of cattle, poultry, &c. (particulary to pigeon's dung, the most powerful manure of its kind), all which, by being dried and powdered before they are used, lose a great portion of their activity. From these observations another fact may be deduced, namely, that manure should not be taken from the place where it has been thrown together until the season of the year and the state of the land are such that it may be put into the ground as soon as it is brought to it. In some districts a very injurious custom prevails of carrying the manure into the fields, and leaving it there formed into small heaps, exposed for some days to the elements; during which time, either the sun or wind dry up its natural moisture, leaving a mass which is much less active; or the rain dissolves and carries away the extractive part impregnated with the salt. This kind of brine, which is the most powerful part of the manure, penetrates the earth to a considerable depth, and shews (by the thick tufts which arise in those places, and which produce more straw than grain) that manure ought to be put into the ground as soon as it is brought to it, because it then possesses its full force and effect, and consequently would be then used to the greatest advantage.

"We have always at hand the means of composing, from a great variety of vegetable and animal substances, such manures as, when brought into a proper state, and mixed with land, contribute to its fertility. Chemistry also offers to us a number of substances, which, although when used separately they tend to diminish the fertilising quality of the earth, are yet capable, by being combined, of forming excellent manures; such, for instance, is that saponaceous combination which is produced from a mixture of potash, oil, and earth. What an advantage it would be, if, instead of being sparing of manure, the inhabitants of the country would endeavour to increase the number of these resources, and to render them more beneficial, by employing them in a more effectual manner. How many years had passed before it was known that the refuse of apples and pears, after they are pressed (and which used to be thrown away as useless),

(A) We believe they are universally preferable.

ufelefs), is capable of forming as valuable a manure, in cyder and perry countries, as the refufe of grapes does in wine countries."

From what has been obferved, our author concludes, that manures act, in many circumftances, like medicines, and confequently that the fame fort of manure cannot be adapted to every fituation, and every kind of foil; we muft therefore take care to make proper diftinctions between them. Whoever fhall pretend that any particular kind of manure may be ufed, with equal benefit, in grafs-lands corn-fields, vineyards, orchards, kitchen-gardens, &c. ought to be claffed among thofe quacks who undertake to cure all perfons with the fame remedy, without any regard to their age, conftitution, &c. It is probably from not having paid fufficient attention to the forementioned diftinctions, that fome authors have found fault with particular manures, while others have fpoken too highly in their favour. He thinks, however, and we agree with him, that we are ftill in want of a courfe of comparative experiments upon the various kinds of manures, confidered according to their influence with refpect to different foils, fituations, and productions. If this part of rural œconomy were better underftood, we fhould perhaps fee many places in a ftate of cultivation, which, on account of the bad quality of their foil, have hitherto refifted all our endeavours to render them fertile.

Perhaps it would not be proper to difmifs this fubject without noticing Mr Middleton's obfervations on various kinds of manure, which were publifhed in the Tranfactions of the Society of Arts for the year 1799. This gentleman agrees with Mr Parmentier, in recommending the *excrementitious matter of privies* as the moft powerful of all manures on fome kinds of foil; but he differs from him, and we believe from moft writers on agriculture, when he affirms, that *wood afhes*, when fpread on the grafs in February or March, are of very little fervice, and that the afhes of *coal* and even of *peat* are of none upon any kind of land. He likewife affirms *foot* to be of very little value as a manure, *foapmakers wafte* to be of none, or rather to be hurtful; and he feems to confider *malt-duft*, including the duft from the malt-kilns, to be, after the foil of privies, one of the moft powerful manures. He affirms, from his own experience, that, with refpect to fertilifing power, the foil of privies, compared with farm-yard dung, is in the proportion of five to one. See more on the fubject of Manure, under the title VEGETABLE SUBSTANCES, Chap. 2d.

MAOUANA, one of that cluftre of iflands in the South Sea which were difcovered by M. Bougainville, and by him named Navigator's Iflands. It was vifited by La Peroufe in 1787, who defcribes it as exceedingly rich in every animal and vegetable production neceffary to the fuftenance of man. The two frigates which he commanded had no fooner approached the fhore, than he difcovered at the bottom of each creek a number of villages, from whence came innumerable canoes, laden with hogs, cocoa-nuts, and other fruits, which were purchafed for glafs ware. This was in the evening; and next morning the commerce was renewed in the moft friendly manner. As early as the dawn of day, the iflanders had furrounded the two frigates with 200 canoes full of different kinds of provifion, which they would exchange only for beads—in their eftimation diamonds of the firft water. Axes, cloth, and all other articles of commerce, they difdained. Abounding in real bleffings, they were defirous of obtaining fuperfluities alone.

Two boats, filled with empty cafks, were fent afhore for frefh water; and Peroufe himfelf accompanied them in his pinnace. A line of foldiers was pofted between the beech and the Indians, who amounted to about 200, including a great many women and children. The French commander prevailed upon them all to fit down under cocoa trees, that were not more than eight toifes diftant from the fhips boats. Each of them had by him fowls, hogs, parrots, pigeons, or fruit, and all wifhed to fell them at once, which occafioned fome confufion.

The women, fome of whom were very pretty, offered their favours, as well as their fowls and fruit, to all thofe who had beads to give them; and foon tried to pafs through the line of foldiers, who oppofed but a feeble refiftance to their attempts. Europeans who have made a voyage round the world, efpecially Frenchmen, have no arms to ward off fimilar attacks. Accordingly the fair favages found little difficulty in breaking the ranks; the men then approached; and the confufion was growing general; when Indians, who feemed to be chiefs, made their appearance with fticks in their hands, and reftored order, every one returning to his poft, and the traffic beginning anew, to the great fatisfaction of both buyers and fellers.

While all this was paffing with the greateft tranquillity, and the cafks were filling with water, Peroufe thought he might venture to the diftance of 200 yards to vifit a charming village, fituated in the midft of a wood, or rather of an orchard, all the trees of which were loaded with fruit. The houfes were placed upon the circumference of a circle, of about 150 toifes in diameter, the interior forming a vaft open fpace, covered with the moft beautiful verdure, and fhaded by trees, which kept the air delightfully cool. Women, children, and old men, accompanied him, and invited him into their houfes. They fpread the fineft and frefheft mats upon a floor formed of little chofen pebbles, and raifed about two feet above the ground, in order to guard againft humidity. He went into the handfomeft of thefe huts, which probably belonged to a chief; and great was his furprife to fee a large cabin of latice-work, as well executed as any of thofe in the environs of Paris. The beft architect could not have given a more elegant curve to the extremities of the ellipfis that terminated the building; while a row of pillars, at five feet diftance from each other, formed a complete colonnade round the whole. The pillars were made of trunks of trees very neatly wrought, and between them were fine mats laid over one another with great art, like the fcales of a fifh, and drawing up and down with cords, like our Venetian blinds. The reft of the houfe was covered with leaves of the cocoa palm.

This charming country combines the advantages of a foil fruitful without culture, and of a climate which renders clothing unneceffary. The trees that produce the bread fruit, the cocoa nut, the banana, the guava, and the orange, hold out to thefe fortunate people as abundance of wholefome food; while the fowls, hogs, and dogs, which live upon the furplus of thefe fruits, afford them an agreeable variety of viands. What cold imagination could feparate the idea of happinefs from

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Mason. fo enchanting a place! But Maouna is not the abode of innocence. No arms were indeed perceived; but the bodies of the Indians, covered over with fcars, proved that they were often at war, or elfe quarrelling among themfelves; while their features announced a ferocity that was not perceptible in the countenances of the women. Nature had, no doubt, ftamped this character on their faces, by way of fhewing, that the half-favage, living in a ftate of anarchy, is a more mifchievous being than the moft ferocious of the brute creation.

Of their ferocity and their treachery, Peroufe had too foon the moft complete evidence. M. de Langle, the fecond in command, went afhore for frefh water, accompanied by fixty Frenchmen, officers, failors, and foldiers. They were received with an air of good humour by crowds of people waiting on the beach with immenfe quantities of fruit and hogs; but this calm was of fhort duration. The Indians picked a quarrel with them, pelted them with ftones, thrown with great dexterity and with equal force; and it was with difficulty that, of the fixty-one, forty-nine reached the fhips, many of whom were feverely wounded. Among the killed were De Langle, and Lamanon the naturalift (fee LAMANON in this *Suppl.*) Peroufe defcribes the men of Maouna as of gigantic ftature, and of great mufcular ftrength. See *NAVIGATORS Iflands* in this *Suppl.*

MASON (the Rev. William) was a man of fuch eminence both as a poet and as a fcholar, that a more particular account of his life and of his ftudies fhould be publifhed than our fcanty materials enable us to give. He was born at Hull, where his father poffeffed the vicarage of St Trinity; but where he received his fchool education we have not been able to learn. At the proper time he was admitted into St John's College, Cambridge; where he took the degrees of B.A. and M.A. and in 1747, he obtained a fellowfhip in Pembroke Hall. It was there that he contracted an intimate friendfhip with Gray the poet, and with Mr Hurd, now Bifhop of Worcefter. When the former of thefe gentlemen died, Mr Mafon took upon himfelf the office of editor of his works and guardian of his fame; and upon the promotion of the latter to the fee of Litchfield and Coventry, he expreffed his fatisfaction in fome beautiful verfes, which we read at the time, but do not recollect where.

In 1754 he entered into holy orders, and was patronifed by the then Earl of Holdernefs, who obtained for him the appointment of chaplain to the king, and prefented him with the valuable rectory of Afton in Yorkfhire. He was fome time afterwards made precentor of York Cathedral, when he publifhed a fmall volume of church mufic, which has alternately met with oppofition and applaufe. In our opinion fome of his anthems are unrivalled.

It was natural for the precentor of a cathedral church, who was likewife a poet, to turn his attention to facred mufic; and Mafon had been a poet from his early years. His *Elfrida* and *Caractacus*, two tragedies on the Grecian model, were both publifhed before the year 1757. Thefe two dramas, in the opinion of Dr Hurd, do honour to modern poetry, and are, according to him, a fufficient proof of the propriety of reviving the chorus on the Britifh ftage. In this fentiment few critics, we believe, will agree with his Lordfhip; but the tragedies have certainly great merit, and tranfcend perhaps every poem of the fame caft in our own or any other modern tongue. In the firft, the language is elegant and fweet; in the latter, it is daring and fublime. The author himfelf always confidered the former as the moft perfect; and Johnfon, whofe critical judgment will not be rafhly queftioned, feems to have been of the fame opinion. Johnfon's partiality to Oxford, as is well known, made him embrace every opportunity of turning into ridicule Cambridge men and Cambridge poems; but while he boafted of having fpent hours in burlefquing Caractacus for the amufement of his Oxford friends, he confeffed that Elfrida was too beautiful to be hurt by ridicule. The voice of the public, however, feems to give the preference to the latter, and to confider it as ftanding, like Dryden's celebrated ode, without a rival. In both are fentiments and expreffions which would do honour to the genius of Shakefpeare; and Caractacus, in the Greek verfion of Mr Glafs, would not have difgraced an Athenian theatre.

Befides his two tragedies, Mr Mafon publifhed many other poems. His Englifh Garden is univerfally read and admired, being unqueftionably the fineft poem of the kind that has appeared fince the days of Thomfon; though fome have affected to confider it as treating the fubject rather with profeffional fkill than with poetical genius. That there are in it a few profaic expreffions we fhall not controvert; for fuch feem infeparable from didactic poetry; but, taken as a whole, where fhall we find its equal? His elegies, particularly that on the death of his wife, and that on the demife of Lady Coventry, have been generally read and extolled, though not more than they deferve, as fuperior in claffic elegance to any thing of the kind in the Englifh tongue, and expreffing a manlinefs and tendernefs of the pathetic, rarely found in the moft polifhed elegies of Roman writers. The fplendor of genius, and accuracy of judgement, confpicuous in his dramas, are equally difplayed in his character as a lyric writer. His quarry was bold and impetuous, and he never fwept the ground with an ignominious flight. In his Sappho and Phaon he has happily imitated the ftyle of Dryden and Metaftafio; and at his death he was employed on a poem in which he propofed to meafure his ftrength with Dryden.

We have reafon to believe that this ingenious man was not only a poet and a mufical performer, but the inventor of the fafhionable inftrument the Piano Forte. We cannot indeed at prefent bring evidence of this fact; but we have inftituted fuch inquiries as, we hope, fhall enable us to afcertain the truth under the article *PIANO Forte*.

Poetry and mufic, and the duties of his office, might be fuppofed to have employed all his time; but, unfortunately, he caught the alarm which in 1769 was fpread over the nation by the expulfion of Mr Wilkes from the Houfe of Commons, and immediately enrolled himfelf among the fupporters of the *Bill of Rights*. The decifion of the Houfe, which pronounced Mr Lutteral duly elected in oppofition to Mr Wilkes, he confidered as a grofs violation of the rights of the people; and though he furely did not approve of the conduct of the exiled member, he joined with other freeholders in Yorkfhire in a petition to the king that he would diffolve the parliament.

Being now leagued with the oppofition, he joined in fome violent clamours for a parliamentary reform. In the

Mafon. the year 1779, when the city of London, and fome other commercial towns, agreed to prefent their petitions to parliament for a more economical expenditure of the public money, and a more equal reprefentation of the people, Mr Mafon came forward, and took an active part in promoting thefe defigns, as one who was convinced of their importance and neceffity. When the county of York affembled, on the 30th of December 1779, and refolved unanimoufly, "that a committee of correfpondence fhould be appointed, for the effectually promoting the object of the petition then agreed to, and alfo to prepare a plan of *affociation* to fupport that laudable reform, and fuch other meafures as may conduce to reftore the *freedom of parliament*," he was chofen upon the committee, and was confulted with, or affifted in drawing up thofe various high-fpirited refolutions and addreffes to the public, for which the Yorkfhire committee was fo celebrated; and which was afterwards generally adopted by the other affociated bodies of reformers. This part of his conduct is furely entitled to no praife. Thinking as we do of the parliamentary reformers, we cannot but regret that a man of Mr Mafon's talents and virtues fhould have embarked in their dangerous purfuits; and though we perceived lefs hazard in thofe purfuits than we do, we fhould ftill confider them as unfuitable to the character of a clergyman. Our author, however, was of a different opinion. In reply to a cenfure paffed by a dignified clergyman on the political conduct of himfelf and fome of his reverend brethren, he publifhed, without his name indeed, a fpirited defence of their proceedings and defigns in fome of the country papers. The York committee, too, at its next meeting, refolved, "that a Proteftant, by entering into holy orders, does not abandon his civil rights;" they alfo refolved, "that the thanks of the committee be given to thofe reverend gentlemen who, thus preferring the public good to their own private emoluments, have ftood forth the firm friends to the true interefts of their country."

Mr Mafon, however, fhowed, by his fubfequent conduct, that however earneftly he might wifh for what he doubtlefs confidered as an expedient reform in the commons-houfe of Parliament, he was firmly attached to the Britifh conftitution. He was indeed a whig; but he was a whig of the old fchool. In the beginning of 1794, when the reformers had betrayed the principles of French democrates, he deferted them, and ranged himfelf under the banners of the fervants of the crown; and for this conduct, which was certainly confiftent, he has been plentifully traduced by our Jacobin journalifts as an alarmift, who not only deferted his old friends, but afcribed to them a certain degree of guilt and political depravity.

The death of this great and good man, which happened in April 1797, was occafioned neither by age nor by inveterate difeafe. As he was ftepping into his chariot, his foot flipped, and his fhin grazed againft the ftep. This accident had taken place feveral days before he paid the proper attention to it; and on April the 3d a mortification enfued, which, in the fpace of forty-eight hours, put a period to his life.

That he was a fcholar and a poet of high eminence is univerfally acknowledged; and we are affured, that his pofthumous works, when publifhed, will not detract from his living fame. In private life, though he affected perhaps too much the faftidious manners of Mr Gray, whofe genius he eftimated with a degree of enthufiafm amounting almoft to idolatry, his character was diftinguifhed by philanthropy and the moft fervid friendfhips; and he may be confidered as a man who merits to be ranked with the ableft fupporters of Britifh liberty and Britifh morals.

Mafonry. FREE MASONRY, is a fubject which, after the copious detail given in the *Encyclopædia* of its lodges, and wardens, and grand mafters, we fhould not have refumed in this place, but to warn our countrymen againft the pernicious fuperftructures which have been raifed by the French and Germans on the fimple fyftem of Britifh mafonry.

Much falfehood is current refpecting the origin and antiquity of the mafonic affociations. That the Dionyfiacs of Afia Minor were a fociety of architects and engineers, who had the exclufive privilege of building temples, ftadia, and theatres, under the myfterious tutelage of Bacchus, feems to be unqueftionable. "We are alfo certain, that there was a fimilar trading affociation during the dark ages in Chriftian Europe, which monopolized the building of great churches and caftles, and enjoyed many privileges under the patronage of the various fovereigns. Circumftances (fays Dr Robifon), which it would be tedious to enumerate and difcufs, continued this affociation longer in Britain than on the continent;" but there is no good evidence, that, anterior to the year 1648, any man fought admiffion into it, who was not either a builder by profeffion, or at leaft fkilled in the fcience of architecture. At that period, indeed, Mr Afhmole, the famous antiquary (fee ASHMOLE, *Encycl.*), was admitted into a lodge at Warrington, together with his father-in-law Colonel Mainwaring: and thefe are the firft diftinct and unequivocal inftances that we have in Britain of men unconnected with the operative mafons being received into their myfterious fraternity. The fecrecy, however, of the lodges, made them fit places for the meetings of the royalifts; and accordingly many royalifts became free mafons. "Nay, the ritual of the mafter's degree feems to have been formed, or perhaps twifted from its original inftitution, fo as to give an opportunity of founding the political principles of the candidate, and of the whole brethren prefent. For it bears fo eafy an adaptation to the death of the king, to the overturning of the venerable conftitution of the Englifh government of three orders by a mean democracy, and its re-eftablifhment by the efforts of the loyalifts, that this would ftart into every perfon's mind during the ceremonial, and could hardly fail to fhew, by the countenances and behaviour of the brethren, how they were affected."

This fuppofition receives much countenance from the well known fact, that "Charles II. was made a mafon, and frequented the lodges. It is not unlikely, that befides the amufement of a vacant hour, which was always agreeable to him, he had pleafure in meeting with his loyal friends, and in the occupations of the lodge, which recalled to his mind their attachment and fervices. His brother and fucceffor James II. was of a more ferious and manly caft of mind, and had little pleafure in the frivolous ceremonies of mafonry. He did not frequent the lodges. But, by this time, they were the refort of many perfons who were not of the profeffion, or members of the trading corporation. This circum-

Masonry. ſtance, in all probability, produced the denominations of *free* and *accepted* maſons. A perſon who has the privilege of working at any incorporated trade, is ſaid to be a *freeman* of that trade. Others were *accepted* as brethren, and admitted to a kind of honorary freedom; as is the caſe in many other trades and incorporations, without having, (as far as we can learn for certain) a legal title to earn a livelihood by the exerciſe of it."

It was not till ſome years after this period that the lodges made open profeſſion of the cultivation of general benevolence, and that the grand aim of the fraternity was to enforce the exerciſe of all the ſocial virtues. The eſtabliſhment of a fund for the relief of unfortunate brethren did not take place till the very end of the laſt century; and we may preſume, that it was brought about by the warm recommendations of ſome benevolent members, who would naturally enforce it by addreſſes to their aſſembled brethren. Hence the probable origin of thoſe philanthropic diſcourſes, which are occaſionally delivered in the lodges by one of the brethren as an official taſk.

The boaſted philanthropy of maſons ſerves, however, another purpoſe. The inquiſitive are always prying and teazing, eager to diſcover the ſecrets of their neighbours; and hence the brethren are induced to ſay, that univerſal beneficence is the great aim of the order, for it is the only point on which they are at liberty to ſpeak. They forget, that univerſal beneficence and philanthropy are inconſiſtent with the excluſive and monopolizing ſpirit of an aſſociation, which not only confines its benevolence to its own members (like any other charitable aſſociation), but hoards up in its boſom ineſtimable ſecrets, whoſe natural tendency, they ſay, is to form the heart to this generous and kind conduct, and inſpire us with love to all mankind. The profane world cannot ſee the beneficence of concealing from public view a principle or a motive which ſo powerfully induces a maſon to be good and kind. The brother ſays, that publicity would rob it of its force; and we muſt take him at his word: and our curioſity is ſo much the more excited, to learn what are the ſecrets which have ſo ſingular a quality, for they muſt be totally unlike the principles of ſcience, which produce their effects only when made public.

From this account of maſonry, it would appear to have been at firſt a loyal aſſociation, and as ſuch it was carried over from England to the continent; for all the maſons abroad profeſs to have received their myſteries from Great Britain. It was firſt tranſported into France by the zealous adherents of King James, who, together with their unfortunate maſter, took refuge in that country; and it was cultivated by the French in a manner ſuited to the taſte and habits of that highly poliſhed and frivolous people. To the three ſimple Britiſh degrees of *apprentice*, *fellow-craft*, and *maſter*, they gradually added degrees innumerable, all decorated with ſtars and ribbons; and into their lodges they introduced the impieties and ſeditious doctrines of Voltaire and the other philoſophiſts. Indeed, if the account which the Abbè Barruel gives of maſonry be juſt, it muſt be admitted, that even the ſecrets of the moſt ancient lodges, though in one ſenſe harmleſs and juſt, are ſo expreſſed, that they may be eaſily twiſted to very dangerous purpoſes. This author was advanced by a few friends to the degree of maſter, without being obliged to take the oath of ſecrecy; and being furniſhed with the ſigns, he got admiſſion into a lodge, where he heard the ſecret regularly communicated, with all the ordinary forms to an apprentice. "It would be uſeleſs, (ſays he), to deſcribe the ceremonials and trials on ſuch occaſions; for in the firſt degrees, they are nothing more than the play of children. The grand object was the communication of the famous ſecret, when the candidate was ordered to approach nearer to the venerable. At that moment, the brethren, who had been armed with ſwords for the occaſion, drawing up in two lines, held their ſwords, elevated, leaning the points towards each other, and formed what in maſonry is called the *arch of ſteel*. The candidate paſſed under this arch to a ſort of altar elevated on two ſteps, at the furtheſt end of the lodge. The maſter, ſeated in an arm chair, or a ſort of throne, behind this altar, pronounced a long diſcourſe on the inviolability of the ſecret which was to be imparted, and on the danger of breaking the oath which the candidate was going to take. He pointed to the naked ſwords, which were always ready to pierce the breaſt of the traitor; and declared to him that it was impoſſible to eſcape their vengeance. The candidate then ſwore, "that rather than betray the ſecret, he conſented to have his head cut off, his heart and entrails torn out, and his aſhes caſt before the winds." Having taken the oath, the maſter ſaid the following words to him: "My dear brother, the ſecret of maſonry conſiſts in theſe words, EQUALITY AND LIBERTY; *all men are equal and free; all men are brethren*.". The maſter did not utter another ſyllable, and every body embraced the new *brother equal and free*. The lodge broke up, and we gayly adjourned to a maſonic repaſt." Maſonry.

In the Britiſh lodges, the author admits, that no other interpretation is given to this famous ſecret, than that, as all men are children of one common parent, and creatures of the ſame God, they are in duty bound to love and help each other as brethren; but he contends, that in France it was differently interpreted; and he ſupports his opinion by the following arguments:

On the 12th of Auguſt 1792, Louis XVI. was carried a priſoner to the tower of the *temple*, ſo called becauſe it formerly belonged to the knights templars. On that day, the rebel aſſembly decreed, that to the date of *liberty* the date of *equality* ſhould be added in future in all public acts; and the decree itſelf was dated the fourth year of *liberty*, the firſt year and firſt day of *equality*. It was on that day, for the firſt time, that the ſecret of free-maſonry mas made public; that ſecret ſo dear to them, and which they preſerved with all the ſolemnity of the moſt inviolable oath. At the reading of this famous decree, they exclaimed, "We have at length ſucceeded, and France is no other than an immenſe lodge. The whole French people are free maſons, and the whole univerſe will ſoon follow their example."

"I witneſſed (ſays our author) this enthuſiaſm; I heard the converſation to which it gave riſe; I ſaw maſons, till then the moſt reſerved, who freely and openly declared, 'Yes, at length the grand object of free-maſonry is accompliſhed, EQUALITY and LIBERTY; *all men are equal and brothers; all men are free*. That was the whole ſubſtance of our doctrine, the object of our wiſhes, *the whole of our grand ſecret!*'"

This is a very ſerious charge againſt the original ſecret

Masonry. cret of masonry, as it was understood in France; and though the author does not bring it directly against the same secret as understood in Britain, he yet seems to say, that in *all* lodges, the following question is put to the candidate before he is entrusted with any secret:—"Brother, are you disposed to execute all the orders of the grand-master, though you were to receive contrary orders from a king, an emperor, or any other sovereign whatever?" And as the brother is obliged to promise this unlimited obedience, it is easy to conceive how much a traiterous conspiracy may be promoted by means of mason lodges. The allegorical story which is told at the conferring of the degree of master, is capable of various and even contrary interpretations; for though in this country it was originally rendered subservient to the purposes of the royalists, in the occult lodges on the continent it has been made the vehicle of treason and impiety.

When the degree of master-mason is to be conferred, the lodge is hung round with black. In the middle is a coffin covered with a pall, the brethren standing round it in attitudes denoting sorrow and revenge. When the new adept is admitted, the master relates to him the following history or fable:

"Adoniram presided over the pavement of the workmen who were building the temple of Solomon's orders. They were three thousand workmen. That each one might receive his due, Adoniram divided them into three classes, apprentices, fellow crafts, and masters. He entrusted each class with a word, signs, and a gripe, by which they might be recognised. Each class was to preserve the greatest secrecy as to these signs and words. Three of the fellow-crafts, wishing to know the word, and by that means obtain the salary of master, hid themselves in the temple, and each posted himself at a different gate. At the usual time when Adoniram came to shut the gates of the temple, the first of the three met him, and demanded the *word of the masters*; Adoniram refused to give it, and received a violent blow with a stick on his head. He flies to another gate, is met, challenged, and treated in a similar manner by the second: flying to the third door, he is killed by the fellow-craft posted there, on his refusing to betray the word. His assassins buried him under a heap of rubbish, and marked the spot with a branch of acacia.

"Adoniram's absence gave great uneasiness to Solomon and the masters. He is sought for every where: at length one of the masters discovers the corpse, and, taking it by the finger, the finger parted from the hand; he took it by the wrist, and it parted from the arm; when the master, in astonishment, cried out, *Mac Benac*; which the craft interprets by "*the flesh parts from the bones*."

"Lest Adoniram should have revealed the *word*, the masters convened and agreed to change it, and to substitute the words *Mac Benac*; sacred words, that free-masons dare not pronounce out of the lodges, and there each only pronounces one syllable, leaving his neighbour to pronounce the other."

The history finished, the adept is informed, that the object of the degree he has just received is to recover the word lost by the death of Adoniram, and to revenge this martyr of the masonic secrecy. The generality of masons, looking upon this history as no more than a fable, and the ceremonies as puerile, give themselves very little trouble to search farther into these mysteries.

These sports, however, assume a more serious aspect when we arrive at the degree of elect (*Elu*). This degree is subdivided into two parts; the first has the revenging of Adoniram for its object, the other to recover the *word*, or rather the sacred doctrine which it expressed, and which has been lost.

In this degree of elect, all the brethren appear dressed in black, wearing a breast-piece on the left side, on which is embroidered a death's head, a bone, and a poignard, encircled by the motto of *Conquer or Die*. The same motto is embroidered on a ribband which they wear in saltier. Every thing breathes death and revenge. The candidate is led into the lodge blindfolded, with bloody gloves on his hands. An adept with a poignard in his hand threatens to run him through the heart for the crime with which he is accused. After various frights, he obtains his life, on condition that he will revenge the father of masonry in the death of his assassin. He is shewn to a dark cavern. He is to penetrate into it; and they call to him, Strike all that shall oppose you; enter, defend yourself, and avenge our master; at that price you shall receive the degree of elect. A poignard in his right hand, a lamp in his left, he proceeds; a phantom opposes his passage; he hears the same voice repeat, Strike, avenge Hiram, there is his assassin. He strikes, and the blood flows.—Strike off his head, the voice repeats; and the head of the corpse is lying at his feet. He seizes it by the hair (A), and triumphantly carries it back as a proof of his victory; shews it to each of the brethren, and is judged worthy of the new degree.

Our author says, that he has questioned divers masons whether this apprenticeship to ferocity and murder had never given them the idea, that the head to be cut off was that of kings; but they all affirmed that such an idea had never occurred to them till the French revolution had convinced them of the fact. At this indeed we are not surprised. The assassin of Hiram is no where said to have been a king; and why should the young elect have supposed, that when stabbing that assassin, he was training to be a regicide? The ceremony, however, is certainly ferocious in the highest degree, and obviously calculated to reconcile the masons of the occult lodges to the practice of assassination at the command of their superiors; and when it is remembered, that they are bound to pay obedience to those unseen superiors even against their lawful sovereigns, the atrocities of the revolution would naturally make them interpret this shocking ceremony as it is interpreted by the Abbé.

It was the same with respect to the religious part of this degree, where the adept is at once pontiff and sacrificer with the rest of the brethren. Vested in the ornaments of the priesthood, they offer bread and wine, according to the order of Melchisedec. The secret object of this ceremony is to re-establish religious equality, and to exhibit all men equally priests and pontiffs, to recal the brethren to natural religion, and to persuade them that the religion of Moses and of Christ had violated religious equality and liberty by the distinction of

(A) The reader may easily conceive that this corpse is no more than a mannikin containing bladders full of blood.

of priests and laity. It was the revolution again which opened the eyes of many of the adepts, who then owned that they had been dupes to this impiety, as they had been to the regicide essay in the former part.

Our author treats the fraternity of the occult lodges through the higher degrees of Scotch masonry, those of the Rosicrucians, and that of the knights Kadosch; and sums up his account in the following terms:

"In the two first degrees, that is to say, in those of *apprentice* and *fellow-craft*, the sect begins by throwing out its equality and liberty. After that, it occupies the attention of its novices with puerile games of fraternity or masonic repasts; but it already trains its adepts to the profoundest secrecy by the most frightful oaths.

"In that of *master*, it relates the allegorical history of Adoniram, who is to be avenged; and of the *word*, which is to be recovered.

"In the degree of *elect*, it trains the adepts to vengeance, without pointing out the person on whom it is to fall. It carries them back to the time of the patriarchs, when, according to them, men knew no religion but that of nature, and when every body was equally priest and pontiff. But it had not as yet declared that all religion revealed since the time of the patriarchs was to be thrown aside.

"This last mystery is only developed in the Scotch degrees. There the brethren are declared free: The word so long sought for is, Deism; it is the worship of Jehovah, such as was known to the philosophers of nature. The true mason becomes the pontiff of Jehovah; and such is the grand mystery by which he is extricated from that darkness in which the prophane are involved.

"In the degree *Rosæ Crucis*, he who wrested the *word*, who destroyed the worship of Jehovah, is Christ himself, the author of Christianity; and it is on the Gospel and on the Son of Man that the adept is to avenge the brethren, the pontiffs of Jehovah.

"At length, on his reception as Kadosch, he learns that the assassin of Adoniram is the king, who is to be killed to avenge the Grand Master Molay, and the order of the masons successors of the knights templars. The religion which is to be destroyed to recover the *word*, or the true doctrine, is the religion of Christ, founded on revelation. This word in its full extent is *equality* and *liberty*, to be established by the total overthrow of the altar and the throne.

"Such are the incipient degrees, the process, and the whole system of masonry; it is thus that the sect, by its gradual explanation of its twofold principle of *equality* and *liberty*, of its allegory of the founder of masonry to be avenged, of the word to be recovered, leading the adepts from secret to secret, at length initiates them into the whole Jacobinical code of revolution."

If this account of masonry be not greatly exaggerated, what are we to think of those men among ourselves, who, since the publication of the Abbè Barruel's book and Dr Robison's, have displayed a zeal for the propagation of their mysteries, by which they seemed not to be formerly actuated, and to which the importance of the business that, by their own account, is transacted in the lodges, cannot be thought to bear an adequate proportion? It is not enough to say that British masonry is harmless, and that the *equality* and *liberty* taught in our lodges are the equality and liberty taught in the bible. Without directly questioning this assertion, we only beg leave to put our countrymen in remembrance, that French and German masonry, as it was derived from Britain, must have been originally as harmless as our own; and to call their attention to the monstrous superstructures of impiety and rebellion which in these countries have been raised upon our foundation. Have there been no symptoms of sedition and irreligion among us, since the commencement of the French revolution, that we should be so confident that the equality and liberty of our lodges will never degenerate into the equality and liberty of the French Jacobins? This cannot be said; for it has been proved, that there are several occult lodges in Britain; and what security have we, or what security can we receive, that their number shall not increase? The legislature indeed has lately laid some salutary restraints on the meetings of masons; but such is the nature of these meetings, that nothing can effectually secure us against the introduction of the higher mysteries, but the voluntary shutting up for a time of all lodges. This has been done by the honest masons in Germany; and why may it not be done by the masons in Britain? The fund for the relief of poor brethren may surely be managed without secrecy; the signs and gripe may be communicated without the *word*, or exacting a promise of implicit obedience; and the relinquishing of the joys of a social hour would be no great sacrifice to the peace of the country.

But is British masonry really so harmless as the younger masons wish us to believe? The writer of these reflections was never initiated in its mysteries, and therefore cannot, from his own knowledge, say what is their tendency; but he has no hesitation to affirm, because he believes himself able to demonstrate, that it is grossly immoral to promise implicit obedience to unknown superiors, or to swear that one will keep inviolate a secret, to the nature of which he is an absolute stranger. He hopes, indeed, and is inclined to believe, that, in the decent lodges of Britain, the candidate is assured, before he is required to take the oath, that the secret to be communicated, and the obedience which he is to pay, militate in no respect against the civil government or the religion of his country: but still if the secret contain information of value, it is, in his opinion, sinful to keep it a secret; and he cannot conceive upon what principle a native of Britain can promise unlimited obedience to any human being. The mysteries of masonry must relate to something which is either important and laudable; frivolous, though innocent; or dangerous and immoral. To confine to a sect any information which is laudable and important, is surely not to act the part of genuine philanthropists; to administer the most tremendous oaths in the midst of frivolous amusements, is to violate one of the most sacred precepts of our holy religion; and, as no man will pretend to vindicate dangerous and immoral mysteries, masonry appears, in every point in which it can be placed, an association which no good Christian will think himself at liberty to encourage.

MASUAH (See MASSUAH, *Encycl.*) is in latitude 15° 35′ 5″ north, and in longitude 39° 36′ 30″ east of Greenwich. On the 22d of September 1769 Mr Bruce found the variation of the needle at Masuah to be 12° 48′ west.

MATMAI, or MATSUMAI, is the largest of the Kurile islands; and if it be not independent, is tributary to to Japan. The capital town of the same name, Matmai, is situated on the sea-shore, on the south-west side. It was built and is inhabited by the Japanese. It is a fortified place, furnished with artillery, and defended by a numerous garrison. The island of Matmai is the place of exile for persons of distinction at Japan: it is separated from that empire by only a narrow channel, but which is considered as dangerous, because the capes, which project on both sides, render the navigation difficult. The people are said to be sensible to friendship, hospitable, generous, and humane.

MAYORGA (Martin de). See *Don Martin*, &c. in this *Suppl.*

MAYOW (John), whose discoveries in chemistry have astonished the scientific part of the public, descended, says Wood, from a genteel family living at *Bree* in the county of *Cornwall*. His father was probably a younger son, bred to business; for our author was born in Fleet-street, London, in the parish of St Dunstan's in the West. At what school he received the rudiments of his education, a circumstance which the biographers of men eminent in the republic of letters should never omit, we have not been able to learn; but on the 27th of September 1661, when he had just completed his 16th year, he was admitted a scholar of Wadham college, Oxford. Some time afterwards, on the recommendation of Henry Coventry, Esq; one of the secretaries of state, he was chosen a probationer fellow of All-souls college. As Wood informs us that he had here a *Legist's place*, an expression by which we understand a law-fellowship, it is not wonderful that he took his degrees in the civil law, though physic and the physical sciences were the favourite objects of his study. He was indeed an eminent physician, practising both in London and in Bath, but in the latter city chiefly in the summer months, till the year 1679, when he died, some time during the month of September, in the house of an apothecary in York-street, Covent-Garden, and was buried in the church of that parish. He had been married, says Wood, a little before his death, not altogether to his content; and indeed he must have been very discontented, if he chose to die in the house of a friend rather than in his own. He published, "Tractatus quinque medico physici, 1. De salnitro; 2. De respiratione; 3. De respiratione fœtus in utero et ovo; 4. De motu musculari et spiritibus animalibus; 5. De Rachitide." These were published together in 8vo at Oxford, in 1764; but there is an addition of two of them, "De respiratione," and "De Rachitide," published together at Leyden in 1671.

The fame of this author has been lately revived and extended by Dr Beddoes, who published, in 1790, "Chemical Experiments and Opinions, extracted from a work published in the last century," 8vo; in which he gives to Mayow the highest credit as a chemist, and ascribes to him some of the greatest modern discoveries respecting air, giving many extracts from the three first of his treatises. His chief discovery was, that oxygen gas, to which he gave the name of *fire air*, exists in the nitrous acid, and in the atmosphere; which he proved by such decisive experiments, as to render it impossible to explain how Boyle and Hales could avoid availing themselves, in their researches into air, of so capital a discovery. Mayow also relates his manner of passing aeriform fluids under water, from vessel to vessel, which is generally believed to be a new art. He did not collect dephlogisticated air in vessels, and transfer it from one jar to another, but he proved its existence by finding substances that would burn in vacuo, and in water when mixed with nitre; and after animals had breathed and died with vessels filled with atmospheric air, or after fire had been extinguished in them, there was a residuum which was the part of the air unfit for respiration, and for supporting fire; and he further shewed, that nitrous acid cannot be formed, but by exposing the substances that generate it to the atmosphere. Mayow was undoubtedly no common man, especially since, if the above dates are right, he was only 34 at the time of his death. But he was not so unknown as Dr Beddoes supposed; for since the repetition of the same discovery by Priestley and Scheele, reference has frequently been made by the chemists to Mayow as the original inventor; thus allowing to him a species of merit, to which he has perhaps but a doubtful claim, and which, if that claim be well founded, must certainly be shared between him and Dr Hooke. See HOOKE in this *Supplement*.

MEAN, in general. See *Encycl.*

Arithmetical MEAN, is half the sum of the extremes. So 4 is an arithmetical mean between 2 and 6, or between 3 and 5, or between 1 and 7; also an arithmetical mean between a and b is $\frac{a+b}{2}$, or $\frac{1}{2}a + \frac{1}{2}b$.

Geometrical MEAN, commonly called a mean proportional, is the square root of the product of the two extremes; so that, to find a mean proportional between two given extremes, multiply these together, and extract the square root of the product. Thus, a mean proportional between 1 and 9, is $\sqrt{1 \times 9} = \sqrt{9} = 3$; a mean between 2 and $4\frac{1}{2}$ is $\sqrt{2 \times 4\frac{1}{2}} = \sqrt{9} = 3$ also; the mean between 4 and 6 is $\sqrt{4 \times 6} = \sqrt{24}$; and the mean between a and b is $\sqrt{ab}$.

Harmonical MEAN. See *Harmonical PROPORTION*, Encycl.

MEAN and Extreme Proportion, or *Extreme and Mean Proportion*, is when a line or any quantity is so divided that the less part is to the greater, as the greater is to the whole.

MEAN Anomaly of a Planet, is an angle which is always proportional to the time of the planet's motion from the aphelion or perihelion, or proportional to the area described by the radius vector; that is, as the whole periodic time in one revolution of the planet, is to the time past the aphelion or perihilion, so is 360° to the mean anomaly. See ANOMALY, *Encycl.*

MEAN Conjunction or *Opposition*, is when the mean place of the sun is in conjunction, or opposition, with the mean place of the moon in the ecliptic.

MEAN Distance of a Planet from the Sun, is an arithmetical mean between the planet's greatest and least distances.

MEAN Motion, is that by which a planet is supposed to move equably in its orbit; and it is always proportional to the time.

MEAN Time or *Equal Time*, is that which is measured by an equable motion, as a clock; as distinguished from apparent time, arising from the unequal motion of the earth or sun.

UNIVERSAL or PERPETUAL MEASURE, is a kind of of meaſure unalterable by time or place, to which the meaſures of different ages and nations might be reduced, and by which they may be compared and eſtimated. Such a meaſure would be very uſeful if it could be attained; ſince, being uſed at all times, and in all places, a great deal of confuſion and error would be avoided.

It has been attempted, at different times and in different countries, more eſpecially by the French, who, ſince the commencement of their revolutionary government, have laboured hard to obtrude their innovations in arts and ſcience, as well as in politics, upon all nations. Propoſals, however, have been made by ſoberer men for a ſtandard both of weights and of meaſures for all nations; and ſome of the moſt rational of theſe ſhall be noticed under the word Weights in this *Supplement*.

MECHANICS.—Our readers will recollect that in the article Physics, *Encycl.* we propoſed to diſtinguiſh by the term *Mechanical Philoſophy* that part of natural ſcience which treats of the local motions of bodies and the cauſes of thoſe phenomena. And, although all the changes which we obſerve in material nature are accompanied by local motion, and, when completely explained, are the effects (perhaps very remote) of thoſe powers of matter which we call *moving forces*, and of thoſe alone, yet in many caſes, this local motion is not obſerved, and we only perceive certain ultimate reſults of thoſe changes of place. This is the caſe (for example) in the ſolution of a grain of ſilver in a phial of aquafortis. In the beginning of the experiment, the particles of ſilver are contained in a ſmall ſpace at the bottom of the phial; but they are finally raiſed from the bottom, and uniformly diſſeminated over the whole fluid. If we fix our attention ſteadily on one particle, and trace it in its whole progreſs, we contemplate nothing but a particle of matter acted on by moving forces, and yielding to their action. Could we ſtate, for every ſituation of the particle, the direction and intenſity of the moving force by which it is impelled, we could conſtruct a figure, or a formula, which would tell us the preciſe direction and velocity with which it changes its place, and we could delineate its path, and tell the time when it will arrive at that part of the veſſel where it finally reſts in perfect equilibrium. Newton having done all this in the caſe of bodies acted on by the moving force called gravity, has given us a complete ſyſtem of mechanical aſtronomy. The philoſopher who ſhall be as fortunate in aſcertaining the paths and motions of the particles of ſilver, till the end of this experiment, will eſtabliſh a ſyſtem of the mechanical ſolution of ſilver in aquafortis; and the theorems and formulæ which characteriſe this particular moving force, or this modification of force, ſtating the laws of variation by a change of diſtance, will be the complete theory of this chemical fact. It is this modification of moving force which is uſually, (but moſt vaguely) called the *chemical affinity*, or the *elective attraction of ſilver and aquafortis*.

But alas! we are, as yet, far from having attained this perfection of chemical knowledge. All that we have yet diſcovered is, that the putting the bit of ſilver into the ſpirit of ſalt will not give occaſion to the exertion of this moving force: and we expreſs this obſervation, by calling that unknown force (unknown, becauſe we are ignorant of the law of its action) an *affinity*, an *elective* attraction. And we have obſerved many ſuch elections, and have been able to claſs them, and to tell on what occaſions they will or will not be exerted; and this ſcrap of the complete theory becomes a moſt valuable acquiſition, and the claſſification of thoſe ſcraps a moſt curious, and extenſive, and important ſcience. The chemical philoſopher has alſo the pleaſure of ſeeing gradual approaches made by ingenious men to the complete mechanical explanation of theſe unſeen motions and their cauſes, of which he has arranged the ultimate reſults.

The ordinary chemiſt, however, and even many moſt acute and penetrating enquirers, do not think of all theſe motions. Familiarly converſant with the reſults, they conſider them as principles, and as topics to reaſon from. They think a chemical phenomenon ſufficiently explained, when they have pointed out the affinity under which it is arranged. Thus they aſcribe the propagation of heat to the expanſive nature of fire, and imagine that they conceive clearly how the effect is produced. But if a mathematical philoſopher ſhould ſay, "What is this which you call an expanſive fluid? Explain to me diſtinctly, in what manner this property which you call expanſiveneſs operates in producing the propagation of heat."—We imagine that the chemiſt would find himſelf put to a ſtand. He will then, perhaps for the firſt time, try to form a diſtinct conception of an expanſive fluid, and its manner of operation. He will naturally think of air, and will reflect on the manner in which air actually expands or occupies more room; and he will thus contemplate local motion and mechanical preſſure. He will find, too late, that this gives him no aſſiſtance; becauſe the phenomena which he has been accuſtomed to explain by the expanſiveneſs of fluids have no reſemblance whatever to what we ſee reſult from the actual expanſion of air. Experience has made him acquainted with many effects which the air produces its expanſion; but they are of a totally different kind from thoſe which he thought that he had ſufficiently explained by the expanſiveneſs of fire. The only reſemblance he obſerves is, that the air and the heat, which were formerly perceived only in a ſmall ſpace, now appear in a much larger ſpace. The mathematician now deſires him to tell in what manner he conceives this expanſiveneſs, or this actual expanſion of air or gas. The chemiſt is then obliged to conſider the air or gas, as conſiſting of atoms or particles, which muſt be kept in their preſent ſituation by an external force, the moſt familiar of all to his imagination, namely, preſſure; and all preſſures are equally fit. Preſſure is a moving force, and can only be oppoſed to ſuch another moving force; therefore expanſiveneſs ſuppoſes, that the particles are under the influence of ſomething which would ſeparate them from each other, if it were not oppoſed by ſomething *perfectly of the ſame kind*. It cannot be oppoſed by greenneſs, nor by loudneſs, nor by fear, but only by what is competent to the production of motion; and it may be oppoſed by any *ſuch* natural power; therefore by gravity, or by magnetiſm, or electricity, or corpuſcular attraction, or by an elective attraction. The chemiſt, being thus led to the contemplation of the phenomenon in its moſt ſimple ſtate, can now judge with ſome diſtinctneſs, what is the nature of thoſe powers with which expanſiveneſs can be

Mechanics. be brought to co-operate or combine. And only now will be able to fpeculate on the means for explaining the propagation of heat; and he will perceive that the general laws of motion, and of the action of moving forces (doctrines which we comprehend under the title of DYNAMICS, *Suppl.*), muft be reforted to for a *complete* explanation of all chemical phenomena. The fame may be faid of the phenomena perceived in the growth of vegetables and animals. All of them lead us ultimately to the contemplation of an atom, which is characterifed by being fufceptible of local motion, and requires for this purpofe the agency of what we call a moving force.

We would diftinguifh this particular OBJECT of our CONTEMPLATION (confifting of two conftituent parts, the atom and the force, related, in fact, to each other by conftant conjunction) by the term MECHANISM. We conceive it to be the charactereftic of what we call MATTER; and we would confider it as the moft fimple MECHANICAL PHENOMENON. We are difpofed to think, that this moving force is as fimple and uniform as the atom to which it is related; and we would afcribe the inconceivable diverfity of the moving forces which we fee around us to combinations of this univerfal force exerted by many atoms at once; and therefore modified by this combination, in the very fame manner as we frequently fee thofe feemingly different moving forces combine their influence on a fenfible mafs of tangible matter, giving it a fenfible local motion. Having formed fuch notions, we would fay that we do not conceive either the atom or the force as being matter, but the two thus related. And we would then fay, that whatever object of contemplation does not ultimately lead us to this complex notion is IMMATERIAL; meaning by the epithet nothing more than the negation of this particular character of the object. It is equivalent to faying, that the phenomenon does not lead the mind to the confideration of an atom actuated by a moving force; that is, moved, or prevented from moving, by an oppofite preffure or force.

Such is the extenfion which the difcoveries of laft century have enabled us to give to the ufe of the term mechanifm, mechanical action, mechanical caufe, &c.

The Greeks, from whom we have borrowed the term, gave it a much more limited meaning; confining it to thofe motions which are produced by the intervention of machines. Even many of the naturalifts of the prefent day limit the term to thofe motions which are the *immediate* confequences of impulfe, and which are cafes of fenfible motion. Thus the chemift fays, that printers ink is a mechanical fluid, but that ink for writing is a chemical fluid. We make no objection to the diftinction, becaufe chemiftry is really a vaft body of real and important fcience, although we have, as yet, been able to clafs only very complicated phenomena, and are far from the knowledge of its elements. This diftinction made by the chemifts is very clear, and very proper to be kept in view; but we fhould be at a lofs for a term to exprefs the analogy which is perceivable between thefe fenfible motions and the hidden motions which obtain even in the chemical phenomena, unlefs we give mechanifm a ftill greater extenfion than the effects of percuffion or impulfion.

Mechanics, in the ancient fenfe of the word, confiders only the energy of *organa*, machines. The authors who have treated the fubject fyftematically, have obferved, Mechanics. that all machines derive their efficacy from a few fimple forms and difpofitions, which may be given to that piece of matter called the *tool* ὄργανον, or *machine*, which is interpofed between the workman or natural agent, and the tafk to be performed, which is always fomething to be moved, in oppofition to refifting preffures. To thofe fimple forms they have given the name of MECHANICAL POWERS, fimple powers, fimple machines.

The machine is interpofed for various reafons.

1. In order to enable a natural power, having a certain determinate intenfity, which cannot be increafed, to balance or overcome another natural power, acting with a greater intenfity. For this purpofe a piece of folid matter is interpofed, connected in fuch a manner with firm fupports, that the preffure exerted on the impelled point by the power occafions the excitement of a preffure at the working point, which is equal or fuperior to the refiftance, arifing from the work, to the motion of that point. Thus, if a rod three feet long be fupported at one foot from the end to which the refiftance of two pounds is applied, and if a preffure of one pound be applied to the other end of the rod, perpendicular to its length, the cohefive forces which connect the particles of the rod will all be excited, in certain proportions, according to their fituation, and the fupported point will be made to prefs on its fupport as much as three pounds would prefs on it; and a preffure in the oppofite direction will be excited at the working point, equal to the preffure of two pounds. The refiftance will therefore be balanced, and it will be overcome by increafing the natural power acting on the long divifion of the rod. This is called a LEVER. Toothed wheels and pinions are a perpetual fucceffion of levers in one machine or mechanical power.

2. The natural power may act with a certain velocity which cannot be changed, and the work requires to be performed with a greater velocity. A machine is interpofed, moveable round a fixed fupport, and the diftances of the impelled and working points are taken in the proportion of the two velocities. Then are we certain, that when the power acts with its natural velocity, the working point is moving with the velocity we defire.

3. The power may act only in one unchangeable direction, and the refiftance muft be overcome in another direction. As when a quantity of coals muft be brought from the bottom of a pit, and we have no power at command but the weight of a quantity of water. We let the water pull down one end of a lever, either immediately or by a rope, and we hang the coals on the other end, while the middle point is firmly fupported. This lever may be made perpetual, by lapping the ropes round a cylinder which turns round an axis firmly fupported. This is a FIXED PULLEY. We can fet unequal powers in oppofition, by lapping each rope round a different cylinder, having the fame axis. This is a WINDLASS or GIN. All thefe forms derive their energy from the lever virtually contained in them.

Any of thefe three purpofes may be gained by the interpofition of a folid body in another way. Inftead of being fupported in one point, round which it is moveable, it may be fupported by a folid path, along which it is impelled, and by its fhape it thrufts the refifting body

Mechanics. body out of its way. This is the cafe with the WEDGE when it is employed to force up a fwagging joift, or prefs things ftrongly together. If this wedge be lapped or formed round an axis, it becomes a SCREW or a SPIRAL WIPER. This is alfo the operation of the balance wheel of a horizontal or cylinder watch. The oblique face of the tooth is a wedge, which thrufts the edge of the cylinder out of its way. The pallet of a clock or watch is alfo a wedge, acted on in the oppofite direction.

Thefe are the different forms in which a folid body is interpofed as a mechanic power. All are reducible to the lever and the wedge.

But there are other mechanic powers befides thofe now mentioned. The carmen have a way of lowering a cafk of liquor into a cellar, by paffing a rope under it, making the end faft to fome ftake clofe to the ground, and bringing the other end of the rope round the cafk, and thus letting it flip down in the bight of the rope. In this procefs they feel but half of its weight, the other half being fupported by the end of the rope that is faftened to the ftake. This is called a PARBUCKLE by the feamen. A hanging pulley is quite the fame with this more artlefs method. The weight hangs by the axis of the pulley, and each half of the hanging rope carries half of the weight, and the perfon who pulls one of them upwards acts only againft half of the weight, the other being carried by the hook to which the ftanding rope is faftened. This mechanical power does not (as is commonly imagined) derive its efficacy from the pulley's turning round an axis. If it were made faft, or if the tackle rope merely paffed through a loop of the rope which carries the weight, it would ftill require only half of the weight acting on the running rope to balance it. The ufe of the motion round an axis is merely to avoid a very great friction. When the two hanging parts of the rope are not parallel, but inclined in any angle, the force neceffary for balancing the weight is to the weight as the fide is to the diagonal of the parallelogram formed by the directions of the three ropes. Varignon calls this the FUNICULAR MACHINE or power. Our failors call it the SWIGG.

We may employ the *quaqua verfum* preffure of fluidity with great effect as a mechanic power. Thus, in the hydroftatic bellows defcribed by Gravefande, § 1451, and by Defaguilliers, the weight of a few ounces of water is made to raife feveral hundred pounds. In like manner, Dr Wallis of Oxford, by blowing with a pipe into a bladder, raifed 64 pounds lying on it. Otto Guericke of Magdeburgh made a child balance, and even overcome, the pull exerted by the emperor's fix coach horfes, by merely fucking the air from below a pifton. Mr Bramah, ironmonger in Piccadilly, London, has lately obtained a patent for a machine acting on this principle as a prefs *. A pifton of one-fourth of an inch in diameter, forces water into a cylinder of 12 inches diameter, and by this intervention raifes the pifton of the cylinder. A boy, acting with the fourth part of his ftrength on the fmall pifton by means of a lever, raifes 42 tons, or 94,080 libs, preffing on the great pifton. It is very furprifing, that this application of the *quaqua verfum* preffure of fluids has been overlooked for more than a century, although the principle has been inculcated and lectured on by every itinerant teacher, and illuftrated by the above mentioned experiments of Gravefande and Wallis; nay, it has been exprefsly taught as a mechanic power of great efficacy by the Profeffor of Natural Philofophy at Edinburgh every feffion of the college for thefe twenty years paft, but he never thought of putting it in practice. It forms a moft compendious machine of prodigious power, and is fufceptible of the greateft ftrength. If the fame multiplication of power be attempted by toothed wheels, pinions, and racks, it is fcarcely poffible to give ftrength enough to the teeth of the racks, and the machine becomes very cumberfome and of great expence. But Mr Bramah's machine may be made abundantly ftrong in very fmall compafs. It only requires very accurate execution. We give it all praife; but Mr Bramah is miftaken when he publifhes it as the invention or difcovery of a new mechanic power: for it has been familiar to every ftudent of mechanics and hydroftatics ever fince Boyle's firft publication of his hydroftatic paradoxes.

* See MACHINERY in this *Suppl.*

Medical, Medici.

MEDICAL JURISPRUDENCE. See *MEDICINA Forenfis* in this *Suppl.*

MEDICI, is the name of an illuftrious family in Florence, which contributed more than perhaps any other family whatever to the revival of letters in Europe. To trace this family from its origin, or even to give biographical fketches of all the great men whom it produced, would occupy by far too great a part of our work; for, during fome centuries, almoft every individual of the houfe of Medici was diftinguifhed among his contemporaries. That houfe, after having rendered itfelf memorable in the annals of Florence, for oppofing the encroachments of the nobles on the liberties of the people, had loft much of its influence under the ariftocratic government of the Albizi, when it was raifed to a rank fuperior to what it had ever held, by

Giovanni de MEDICI, who was born in the year 1360. This man determined to reftore his family to fplendour; but, confcious of his critical fituation, furrounded as he was by powerful rivals and enemies, he affected rather a fecure privacy than a dangerous popularity. Even when raifed to the office of gonfalonier, or generaliffimo of the republic, he carefully avoided any defire of partaking in the magiftracy, and feemed to be entirely engroffed by merchandize, which he extended from the Eaft throughout Europe. This conduct, as on one hand it threw his enemies off their guard, on the other, enabled him to acquire an immenfe fortune, of which he made a proper difpofition amongft all ranks of people.

Many, even of the ruling party, either gained by his liberality, or pleafed with his amiable and retired conduct, propofed to the feigniory to admit him into the magiftracy; and though the propofal met with great oppofition, it was carried in the affirmative.

It was by rafhly declaring for the plebeians againft the nobles that an anceftor of Giovanni's had loft to his family their rank in the ftate. Giovanni, refolving not to fplit on the fame rock, continued to affect privacy and retirement, accepting any office in the ftate with the utmoft appearance of reluctance, and never attending at the Palazzo, unlefs particularly fent for by the feigniory. Rifing by thefe means in the efteem of the people, his enemies became, of courfe, unpopular; and having obtained a decided fuperiority over his opponents, he now ventured to procure, that thofe taxes which the nobles had exacted with the utmoft feverity and partiality from the people alone, fhould be levied

upon

Medici. upon the two firſt orders, in common with the plebeians; and that a law ſhould be ordained, by which perſonal property might be taxed.

The nobles ſeeing, with the deepeſt concern, their conſeqence ſo ſenſibly wounded, and their power ſo much diminiſhed, held ſeveral conſultations in private how they might effect his ruin; but their want of unanimity prevented any thing deciſive from being carried into execution. The people, alarmed for the ſafety of their leader and patron, offered him the ſovereignty, which his relations and friends urged him to accept; but this his prudence forbad him to take, as with the title of lord he would have gained that alſo of tyrant. Thus, by his ſingular prudence he died poſſeſſed of all the power of the ſtate, with the affectation of being the moſt diſintereſted citizen in the commonwealth. His death happened in the year 1428.

Giovanni was graceful in his perſon, and his affability to all eſtabliſhed his character for moderation. His extenſive knowledge and pleaſantry made his company eagerly ſought. As all his actions were placid and ſerene, he was not in want of that trumpet of ſedition, popular declamation, which he never attempted. Much to his honour, his elevation was not procured even by the baniſhment of a ſingle individual; a circumſtance until then unknown in Florence, where every new adminiſtration was marked with the ruin of families, and by ſcaffolds ſtained with blood.

"The maxims (ſays Mr Roſcoe) which, uniformly purſued, raiſed the houſe of Medici to the ſplendour which it afterwards enjoyed, are to be found in the charge given by this venerable old man, on his deathbed, to his two ſons Coſmo and Lorenzo. 'I feel (ſaid he) that I have lived the time preſcribed me. I die content, leaving you, my ſons, in affluence and in health, and in ſuch a ſtation, that, whilſt you follow my example, you may live in your native place honoured and reſpected. Nothing affords me more pleaſure than the reflection, that my conduct has given offence to no one; but that, on the contrary, I have endeavoured to ſerve all perſons to the beſt of my abilities. I adviſe you to do the ſame. With reſpect to the honours of the ſtate, if you would live with ſecurity, accept only ſuch as are beſtowed on you by the laws, and the favour of your fellow-citizens; for it is the exerciſe of that power which is obtained by violence, and not of that which is voluntarily given, that occaſions hatred and contention."

Medici (Coſmo de), the eldeſt ſon of the preceding, was born in 1389. During the life-time of his father, he had engaged himſelf deeply, not only in the extenſive commerce by which the family had acquired its wealth, but in the weightier matters of government. When Giovanni died he was in the prime of life; and though his complexion was ſwarthy, he had an agreeable perſon, was well made, of a proper ſtature, and in converſation united a happy intermixture of gravity with occaſional ſallies of pleaſantry and repartee. His conduct was uniformly marked by urbanity and kindneſs to the ſuperior ranks of his fellow-citizens, and by a conſtant attention to the intereſts and the wants of the lower claſs, whom he relieved with unbounded generoſity. By theſe means he acquired numerous and zealous partizans of every denomination; but he rather conſidered them as pledges for the continuance of the power which he poſſeſſed, than as inſtruments to be employed in extending it to the ruin and ſubjugation of the ſtate. An interchange of reciprocal good offices was the only tie by which the Florentines and the Medici were bound; and perhaps the long continuance of this connection may be attributed to the very circumſtance of its being in the power of either of the parties at any time to have diſſolved it. Medici.

But the prudence and moderation of Coſmo could not repreſs the ambitious deſigns of thoſe rival families, who wiſhed to poſſeſs or to ſhare his authority. In the year 1433, Rinaldo de Albizi, at the head of a powerful party, carried the appointment of the magiſtracy. At that time Coſmo had withdrawn to his ſeat in the country, to avoid the diſturbances which he ſaw likely to enſue; but at the requeſt of his friends he returned to Florence, where he was led to expect ſuch a union of parties, as might at leaſt preſerve the peace of the city. No ſooner did he make his appearance in the palace, where his preſence had been requeſted, on pretence of his being intended to ſhare in the adminiſtration of the republic, than he was ſeized upon by his adverſaries, and committed to priſon.

The conſpirators were divided in their opinions as to the diſpoſal of their priſoner. Moſt of them inclined to follow the advice of Peruzzi, who recommended taking him off by poiſon. Coſmo, confined in the Alberzettino, a room in one of the turrets of the Palazzo, could hear this dreadful conſultation, which was determining, not in what manner he ſhould be tried, but in what manner he ſhould be put to death; and finding that he was to die by an infuſion of poiſon ſecretly adminiſtered to him, a ſmall portion of bread was the only food which he thought proper to take.

Coſmo lived in this manner four days; and, ſhut up from all his kindred and friends, he ſoon expected to be numbered with the dead; but here, as it ſometimes happens, he found relief where leaſt expected, from the man who had been engaged to take him off. Malavolta, the keeper of the priſon, either from compunction, diſſatisfaction, or the youth and misfortunes of the illuſtrious ſufferer, relented; and inſtead of purſuing any criminal intentions againſt the life of Coſmo, after upbraiding him with entertaining ſo unworthy an opinion of him, declared that his fears were entirely groundleſs. To convince him of this, he ſat down, and partook of every thing the priſoner choſe to eat of. The expreſſions of gratitude, together with his moſt engaging manners, and great promiſes, entirely won Malavolta, who, to ingratiate himſelf ſtill farther in the good opinion of Coſmo, invited Fargaccio, the moſt celebrated wit in Florence, to dine with him the next day, from the idea that his ſprightly mirth would contribute to lighten his misfortunes.

In the mean time, his brother Lorenzo, and his couſin Averardo, having raiſed a conſiderable body of men in Romagna and other neighbouring diſtricts, and being joined by the commander of the troops of the republic, approached towards Florence to his relief. The apprehenſion, however, that the life of Coſmo might be endangered, if they ſhould proceed to open violence, induced them to abandon their enterpriſe. At length Rinaldo and his adherents obtained a decree of the magiſtracy, by which Coſmo was baniſhed to Padua for ten years, his brother to Venice for five years; and ſeveral

Medici. veral of their relations and adherents ſhared the ſame fate.

Coſmo received this determination of his judges with a compoſure that gained him the compaſſion and the admiration of many of his moſt inveterate enemies. He would gladly have left the city purſuant to his ſentence; but he was detained by his enemies till their authority ſhould be eſtabliſhed: and it was not till he thought of bribing the gonfalonier, and another creature of Rinaldo's, that he was privately taken from his confinement, and conducted out of Florence.

Padua, to which he was confined by his ſentence, was in the dominions of Venice; but before he could reach that place, he received a deputation from the ſenate, the purport of which was to condole with him for his misfortunes, and to promiſe him their protection and aſſiſtance in whatever he ſhould deſire. He experienced the treatment of a prince rather than that of an exile. Nor were that wiſe people without good reaſons for ſuch a conduct. Venice had long regarded Florence as her rival in commerce, and hoped, by conferring upon Coſmo the moſt flattering diſtinctions, to prevail upon him to reſide there in future; prudently ſuppoſing that the manufactories of Florence, and the great commerce the Medici had carried on throughout Italy, and extended far beyond it to the wealthieſt kingdoms in Europe, would become their own by enrolling him amongſt their ſubjects.

The readineſs with which Coſmo had given way to the temporary clamour raiſed againſt him, and the reluctance which he had ſhewn to renew thoſe rencounters which had ſo often deluged the ſtreets of Florence with blood, gained him new friends, even during his exile. The utmoſt exertions of his antagoniſts could not long prevent the choice of ſuch magiſtrates as were known to be attached to the cauſe of the Medici; and no ſooner did they enter on their office than Coſmo and his brother were recalled, and Rinaldo with his adherents were compelled to quit the city. This event took place about a year after the baniſhment of Coſmo.

The ſubſequent conduct of this great man (for great all allow him to have been) has been painted in different colours by different writers. Mr Noble, after Machieval, compares his cruelties to his fallen foes with thoſe of Sylla and Octavius to the partizans of Marius and Brutus; whilſt Roſcoe repreſents his conduct as in a high degree amiable and generous. It appears to us evident, from his own words, that he had exerciſed ſome cruelties on his exiled enemies; for when one of them wrote to him, that "the hen was hatching," he replied, "She will have but a bad time of it, ſo far from her neſt." When ſome other exiles acquainted him that "they were not aſleep," he anſwered, "he could eaſily believe that, for he thought he had ſpoiled their ſleeping." At another time, ſome of the citizens remonſtrated with him upon the odiouſneſs of his conduct in baniſhing ſo many perſons; telling him "the republic would be extremely weakened, and God offended, by the expulſion of ſo many good and pious men as he was ſending into baniſhment." His anſwer was, "it would be better for the republic to be weakened than utterly ruined; that two or three yards of fine cloth made many a one look like a good man: but that ſtates were not to be governed or maintained by counting a ſtring of beads, and mumbling over a few *Pater noſters*."

From this time the life of Coſmo de Medici was an almoſt uninterrupted ſeries of proſperity. His misfortunes had taught him, that the affectation of grandeur is more dangerous in a free ſtate than uſurpation. He adopted, therefore, the dreſs, behaviour, and manners, of a private citizen. His clothes were of the ſame faſhion and materials as the reſt of the Florentines. In the ſtreets he walked alone and unguarded. His table was ſupplied from what his eſtate of Mugello produced, nor had he one ſervant more than was abſolutely neceſſary; thus endeavouring to unite the character of a prince with that of a merchant, and a private perſon in a republic.

Whilſt he rejected all offices in the magiſtracy, no buſineſs was tranſacted without its being firſt ſettled at Mugello: nor did he contract any alliances but with the ſons and daughters of the citizens of Florence; yet all foreign princes and courts paid his children the reſpect due only to thoſe of ſovereigns; and the family of Coſmo received educations equal to thoſe of the greateſt potentates.

A proper judgment may be formed of his immenſe traffic, and the prodigious advantages accruing from it: For though a private citizen of Florence only, yet he poſſeſſed at one time more money than what was in all the treaſuries of the different ſovereigns in Europe. When Alfonſo king of Naples leagued with the Venetians againſt Florence, Coſmo called in ſuch immenſe debts from thoſe places, as deprived them of reſources for carrying on the war. During the conteſt between the houſes of York and Lancaſter, he furniſhed Edward IV. with a ſum of money ſo great, that it might almoſt be conſidered as the means of ſupporting that monarch on the throne.

In his public and private charities, in the number and grandeur of the edifices he erected, not only in Florence, but in the moſt diſtant parts of the world, and in the foundations which he endowed, he ſeemed to more than vie with majeſty. He ſupplied moſt of the exigencies of the ſtate from his private purſe; and there were few citizens that had not experienced his liberality, and many without the leaſt application, particularly the nobles.

But in nothing did his munificence produce ſo much good to the world, or acquire ſuch honour to himſelf, as when it was exerted for the promotion of ſcience, and the encouragement of learned men; and upon nothing did Coſmo delight ſo much to exert it. The ſtudy of the Greek language had been introduced into Italy towards the latter part of the preceding century; but it had again fallen into neglect. After a ſhort interval, an attempt was made to revive it, by the intervention of Emanuel Chryſoloras, a noble Greek, who taught that language at Florence, and other cities of Italy, about the beginning of the 15th century. His diſciples, who were numerous and reſpectable, kept the flame alive till it received new aid from other learned Greeks, who were driven from Conſtantinople by the dread of the Turks, or by the total overthrow of the Eaſtern Empire. To theſe illuſtrious foreigners, as well as to the learned Italians, who ſhortly became their ſucceſsful rivals, even in the knowledge of their national hiſtory and language, Coſmo afforded the moſt liberal ſupport and protection. The very titles of the works of ancient authors, which were brought to light by his munificence,

nificence, would extend this article beyond its proper limits. Such, indeed, was the eftimation in which thefe works were then held in Italy, that a manufcript of the hiftory of Livy, fent by Cofmo de Medici to Alfonfo king of Naples, with whom he was at variance, conciliated the breach between them.

As the natural difpofition of Cofmo led him to take an active part in collecting the remains of the ancient Greek and Roman writers, fo he was enabled by his wealth, and by his extenfive mercantile intercourfe with different parts of Europe and of Afia, to gratify a paffion of this kind beyond any other individual. To this end he laid injunctions on all his friends and correfpondents, as well as on the miffionaries and preachers who travelled into the remoteft countries, to fearch for and procure ancient manufcripts, in every language, and on every fubject. The fituation of the Eaftern Empire, then falling into ruins, afforded him an opportunity of obtaining many ineftimable works in the Hebrew, Greek, Chaldaic, Arabic, and other eaftern languages. From thefe beginnings arofe the celebrated library of the Medici; which, after various viciffitudes of fortune, and frequent and confiderable additions, has been preferved to the prefent times under the name of the *Bibliotheca Mediceo Laurentiana.*

Nor was Cofmo a mere collector of books, he was himfelf, even in old age, a laborious ftudent. Having been ftruck with the fublime fpeculations of Plato, which he had heard detailed in lectures by a Greek monk, who had come from Conftantinople to the council of Florence, he determined to found an academy for the cultivation of that philofophy. For this purpofe he felected Marfilio Ficino, the fon of his favourite phyfician, and deftined him, though very young, to be the fupport of his future eftablifhment. The education of Ficino was entirely directed to the Platonic philofophy; nor were the expectations which Cofmo had formed of him difappointed. The Florentine academy was fome years afterwards eftablifhed with great credit, and was the firft inftitution in Europe for the purfuit of fcience, detached from the fcholaftic method then univerfally adopted. It is true, the fanciful doctrines of Plato are as remote from the purpofes of life as the fubtleties of Ariftotle; but, by dividing the attention of the learned between them, the dogmas of the Stagyrite were deprived of that fervile refpect which had fo long been paid to them, and men learned by degrees to think for themfelves.

The foftering hand of Cofmo was held out to art as well as to fcience; and architecture, fculpture, and painting, all flourifhed under his powerful protection. The countenance fhewn by him to thefe arts was not fuch as their profeffors generally receive from the great. It was not conceded as a bounty, nor received as a favour, but appeared in the friendfhip and equality that fubfifted between the artift and his patron; and the fums of money, which Cofmo expended on pictures, ftatues, and public buildings, appear almoft incredible.

Cofmo now approached the period of his mortal exiftence; but the faculties of his mind remained unimpaired. About twenty days before he died, he fent for Ficino, and enjoined him to tranflate from the Greek the treatife of Xenocrates on death. Calling into his chamber his wife and his fon Piero, he entered into a narrative of all his public tranfactions; in which he gave a full account of his extenfive mercantile connections, and adverted to the ftate of his domeftic concerns. To Piero he recommended a ftrict attention to the education of his fons; and requefted, that his funeral might be conducted with as much privacy as poffible. He died on the firft of Auguft 1464, at the age of 75 years, deeply lamented by a great majority of the citizens of Florence. Their efteem and gratitude had indeed been fully fhewn fome time before, when, by a public decree, he was honoured with the title of *Pater Patriæ*, an appellation which was infcribed on his tomb; and which, as it was founded, fays Rofcoe, on real merit, has ever fince been attached to the name of Cofmo de Medici.

Medici (Lorenzo de), juftly ftyled the *magnificent*, was the grandfon of Cofmo, and about 16 years of age when his grandfather died. His father Piero de Medici, though poffeffed of more than ordinary talents, as well as of a very confiderable fhare of worth, was, from various circumftances, little qualified to maintain the influence which his family had gained in the republic of Florence. From very early life he had been tortured by the gout; and almoft uninterrupted pain had made him peevifh. Such a difpofition was not calculated to retain the affections of the giddy Florentines, or to perfuade republicans that they were free, while they fubmitted to the government of a fingle individual. All this Cofmo had forefeen, and had done what wifdom could do to preferve to his family that afcendency in the republic which he had himfelf acquired. He exhorted Piero to beftow the utmoft care on the education of his fons, of whofe capacity he expreffed a high opinion; he recommended to him Diotifalvo Neroni, a man whom he had himfelf raifed from obfcurity to an eminent rank, as a counfellor, in whofe wifdom and fidelity he might place the utmoft confidence: and to bind the inhabitants of Florence to the houfe of Medici by the ftrongeft of all ties, he had diftributed among them, under the denomination of loans, immenfe fums, which he knew they would not foon be able to repay.

Piero paid the utmoft deference to the dying injunctions of his father. He had himfelf an ardent love of letters; and under the eye of the venerable Cofmo, he had given his two fons, Lorenzo and Juliano, the beft poffible domeftic education. In the Greek language, in ethics, and in the principles of the Ariftotelian philofophy, Lorenzo, the eldeft, had the advantage of the precepts of the learned Argyropylus (A), and in thofe of the Platonic fect he was feduloufly inftructed by Marfilio Ficino (fee Ficinus, *Encycl.*); but for his moft valuable accomplifhments he was not indebted to any preceptor. To complete his education, however, it was judged expedient that he fhould vifit fome of the principal courts of Italy; and very foon after the death of his grandfather, he repaired to Rome, Bologna, Ferrara, Venice, and Milan, where he gained the efteem of all whofe efteem was of value.

(A) This man had fled from Conftantinople, when it was taken by the Turks, to Florence, where he was protected by Cofmo de Medici.

Medici.

Thus attentive was Piero to the advice of his father with respect to the education of his eldest son; nor was he less attentive to it in the choice of his principal counsellor. He intrusted the whole of his affairs into the hands of Neroni, and gave him Cosmo's accounts to peruse and settle. That ambition, which perhaps had lain lurking in this man's mind, was now called forth, and he basely formed the scheme of ruining the son of his patron, by building upon his misfortunes his own future grandeur. For this purpose, he lamented the absolute necessity there was for an immediate call upon those who were indebted to Piero as Cosmo's representative; telling him that a delay might subject him to the greatest inconveniences. Piero consented, though with reluctance, to his supposed friend's advice. The result was such as Neroni expected. Those who were friends of the father became enemies of the son; and had not Piero discovered the snare, and desisted from such rigorous proceedings, he might have found, when too late, that in supporting the character of the merchant, he had forgotten that of the statesman; for all the citizens of Florence were his debtors.

Soon after this, an attempt was made to assassinate Piero, by a powerful party which had always been inimical to the house of Medici; but it was defeated by Lorenzo, who displayed on that occasion a sagacity and promptitude of mind which would have done honour to the oldest statesman. A few of the conspirators were declared enemies to the state, and condemned to banishment; but by far the greater part of them were pardoned on the solicitation of Lorenzo, who declared, that "he only knows how to conquer, who knows how to forgive."

In the year 1469 Piero de Medici died; and Lorenzo succeeded to his authority as if it had been a part of his patrimony, being requested by the principal inhabitants of Florence, that he would take upon himself the administration of the republic in the same manner that his grandfather and father had done.

In the month of December 1470, a league was solemnly concluded between the pope, the king of Naples, the duke of Milan, and the Florentines, against Mahomet II. who had vowed not to lay down his arms till he had abolished the religion of Christ, and extirpated all his followers. The pope, however, (Paul II.), died on the 26th of July 1471; and Sixtus IV. succeeding to the chair of St Peter, Lorenzo was deputed from Florence to congratulate him on his elevation. Two more opposite characters can hardly be conceived than those of Sixtus and Lorenzo. The former was cruel, treacherous, and sordid; the latter was merciful, candid, and generous. Yet such instances of mutual good will took place between them on this occasion, that Lorenzo, who, under the direction of his agents, had a bank established at Rome, was formally invested with the office of treasurer of the Holy See.

Pisa had been under the dominion of Florence from the year 1406, and it had acquired some celebrity on account of its academy, which had existed almost two centuries. That academy, however, had fallen into decay; and, in the year 1472, the Florentines resolved to restore it to its pristine splendour. Five citizens, of whom Lorenzo de Medici was one, were appointed to superintend the execution of their purpose; but Lorenzo, who was the projector of the plan, undertook the chief management of it; and, in addition to 6000 florins annually granted by the state, expended, in effecting his purpose, a large sum of money from his private fortune. In doing this, he only imitated the example of his father and grandfather; for in the course of 37 years, reckoning from the return of Cosmo from banishment, this illustrious family had expended on works of charity or public utility upwards of 660,000 florins. "Some persons (said Lorenzo) would perhaps be better pleased to have a part of it in their purse; but I conceive that it has been of great advantage to the public, and well laid out, and am therefore perfectly satisfied."

In the year 1474, Lorenzo incurred the displeasure of the pope for opposing some of his encroachments on the petty princes of Italy; and the revenge planned by Sixtus was of such a nature as would have disgraced, we do not say a Christian bishop, but the rudest savage. He began by depriving Lorenzo of the office of treasurer of the Roman See, which he gave to the Pazzi, a Florentine family, who, as well as the Medici, had a public bank at Rome. By this step he secured the interest of the Pazzi, who, it is probable, were to govern Florence under the pope, when Lorenzo and Juliano de Medici should be cut off, and their friends and adherents driven from the republic. The principal agent engaged in the undertaking was Fransesco Salviati archbishop of Pisa, to which rank he had lately been promoted by Sixtus, in opposition to the wishes of the Medici. The other conspirators were Giacopo Salviati, brother to the archbishop; Giacopo Poggio, one of the sons of the celebrated Poggio Bracciolini (see POGGIUS, *Encycl.*); Barnardo Bandini, a daring libertine, rendered desperate by the consequence of his excesses; Giovanni Battisti Montesicco, who had distinguished himself as general of the pope's armies; Antonio Maffei, a priest of Volterra; and Stephano de Bagnona, one of the apostolic scribes; with several others of inferior note. The cardinal Riario, then at Pisa, was likewise an instrument in the conspiracy; but he can hardly be considered as an agent, for he was kept ignorant of what was going on, and enjoined only to obey whatever directions he might receive from the archbishop of Pisa.

The assassination of the illustrious youths was fixed for Sunday, April 26. 1478; the place the cathedral of Florence, at the moment the host was to be elevated; and their murder was to be the signal for seizing and expelling from the walls of the city all their relations and friends. What a transaction this for one who presumed to style himself the vicar of Christ, the common father of Christendom, to patronize!

The fatal day arrived, and Lorenzo was already in the church; but Juliano remained at home, occasioned by a slight indisposition. The conspirators, determining not to lose one of their victims, went to invite, to intreat him, to go. They embraced (B), and led him, by a tender violence, to the cathedral. The signal was given

(B) The assassins embraced Juliano, to discover whether he wore any secret armour, that they might know whre to strike with the surest aim.

Medici. given by the elevation of the consecrated wafer; and whilst the people fell upon their knees to adore, the assassins rose, and, as was concerted, two of them, Francisco Pazzi and Barnardo Bandini, fell upon Juliano. The latter directed his poignard so truly, that it entered into the bosom of the unoffending youth, and he fell mortally wounded at his feet.

In a moment, as must be supposed, all was confusion. Lorenzo, alarmed, put himself in a posture of defence, when in an instant, Antonio of Volterra, and Stephano a priest, the dependant of the archbishop, who, upon Giovanni Battisti's declining the infamous task, undertook his destruction, rushed upon him as their destined prey. The contest continued some time. Lorenzo had received a wound in his neck, and seemed to contend for his life in vain; but a servant, whom he had lately relieved from prison, inspired by gratitude, heroically threw himself between his beloved lord and his assassins, receiving in his body those weapons that were aimed at the breast of Lorenzo. This fidelity saved him; for by one vigorous effort he broke from Antonio and Stephano, and with a few friends rushed into the sacristy, shutting the doors behind them, which were of brass. Apprehensions being entertained, that the weapon which had wounded him was poisoned, a young man sucked the wound, endangering his own life to save that of Lorenzo.

The rage of the people to see one of their favourites expiring, and the other covered with blood, was inexpressible. The cardinal Riario found it difficult to save his life at that altar which he had stained by so horrid a deed, and to which he then fled for protection.

Whilst this infamous scene was acting in the cathedral, others of the conspirators were attempting to seize the Palazzo; but with no better success. The archbishop Salviatti, who had undertaken to head them, gave the magistrates suspicion by those violent emotions which agitated his whole frame. The nine senators who composed the magistracy, including the gonfalonier, who had been appointed by, and were, in other words, the privy council of the Medici, immediately attacked those who intended to have surprised them; and Salviatti and his followers had no sooner gained the second floor, than they found themselves prisoners.

Jacobo Pazzi soon appeared in the street, proclaiming, with exultation, the murder of Juliano; and inviting the Florentines to free themselves from the Medicean slavery; but perceiving that he was not joined by the people, the magistrates sent off 100 horse to the rescue of Lorenzo. This was the more to be commended, because they continued to be assaulted by the conspirators, who finding their situation desperate, forced themselves to the ground floor, determining, if possible, to seize the Palazzo. The magistrates, with their attendants, acted with such resolution and valour, that as often as they gained an entrance they drove them back, killing some of the assailants upon the spot, others they threw out of the windows upon the pavement; and to strike an awe into those that were without, they had the boldness and virtue to hang the archbishop from one of the windows, dressed as he was in his pontifical robes, with Poggio, another of the chief conspirators. Florence resounded in every part with the exclamation — Medici, Medici! down with their enemies!

Lorenzo was liberated from that part of the cathedral to which he had fled, and conveyed home in triumph, where his wounds were attended to, and where he found himself surrounded by his most valuable friends, to whom he was endeared by the shocking occurrences of the day. His partizans, however, did not spend their time only in lamentations for the death of one of the brothers, and exultations for the preservation of the other; they united in pursuing the conspirators, sparing none that fell into their hands. Jacobo Pazzi was taken flying with his forces into Romania, and immediately hung. An officer of the pope's, who commanded a brigade under Count Hirronimo, had alone the favour of decapitation. Bandini fled privately to Pisa, thence to Naples, and, lastly, to Constantinople; but Mahomet, to oblige Lorenzo, seized, and sent him back; and he was hung out of the same window from which the archbishop had suffered. An embassy was sent from Florence to thank the sultan in the name of the republic. Medici.

Throughout the whole of this just but dreadful retribution, Lorenzo had exerted all his influence to restrain the indignation of the populace. He entreated that they would resign to the magistrates the task of ascertaining and of punishing the guilty, lest the innocent should be incautiously involved in destruction; and his appearance and admonitions had an instantaneous effect. By his moderation, and even kindness to the relatives of the conspirators, he sought to obliterate the remembrance of past disturbances; and by his interference, even the survivors of the Pazzi were restored to their honours, of which they had been deprived by a decree of the state.

The generosity and moderation of Lorenzo had no effect on the temper of Sixtus, who solemnly excommunicated him, the gonfalonier, the magistrates, and their immediate successors; and in the bull which he issued on this occasion, he styles Lorenzo de Medici "the child of iniquity and the nursling of perdition!" Not content with this ebullition of resentment, he suspended the bishops and clergy of the Florentine territories from the exercise of their spiritual functions; thus laying the whole republic under an interdict. This had been a formidable weapon in the hands of his predecessors, who had, by means of it, overawed the most powerful monarchs; but the general character of Sixtus was so infamous, and his present injustice so manifest, that by the exertions of the bishop of Arezzo, a convocation was held in the cathedral church of Florence, in which Sixtus was accused of *fornication* and *adultery*, with other infamous vices; declared to be the principal instigator of the conspiracy against the Medici; and the sentence of excommunication which he had fulminated against Lorenzo and the Florentine magistrates was called in direct terms, the "execrable malediction of a damned judge (*maledictam maledictionem damnatissimi judicis*)!"

How such language could be reconciled to the notions which then prevailed of the sanctity of the pope, and the plenitude of his power, it is needless to inquire; but the reader will not be surprised that the prelates, who made use of it, paid no regard to the interdict of Sixtus. The pontiff, however, did not relax from his purpose. Whilst he brandished with one hand the spiritual weapon, which the Florentines treated with such contempt, in the other he grasped a temporal sword, which he now openly, as he had before secretly, aimed at the breast of Lorenzo. At his instigation the king of Naples

 dispatched

Medici. dispatched an envoy to Florence, to require the citizens to banish Lorenzo from the Tuscan territories, if they would not incur the vengeance both of him and of the pope. These threats produced not the intended effect; for the Florentines avowed their firm resolution to suffer every extremity, rather than betray the man whom they considered as guardian of the republic. War therefore was commenced and the republic was on the point of being ruined, when Lorenzo taking advantage of a truce, threw himself, with a resolution not to be equalled, into the hands of the king of Naples. He judged, perhaps, that any stipulations for his personal safety would be useless with a prince who had sported with honour, justice, mercy, and the most solemn treaties. But, whilst all viewed him as a victim who had devoted himself to save his country, he, by persuasive eloquence, obtained of this crafty perfidious monarch a separate peace, and returned to Florence crowned with a success that no one thought possible, and where he was received as its tutelar deity. The pope, however, continued inflexible, till a descent of the Turks upon Italy restored him to his senses, and made him willing to receive the submission of Florence, and reconcile its inhabitants to the church.

Soon after the termination of the hostilities between Sixtus and the republic of Florence, Lorenzo began to unfold plans for securiug the peace of Italy, which confer the highest honour on his political life. To counterpoise all the jarring interests of the petty states of which that country was composed, to restrain the powerful, succour the weak, and to unite the whole in one firm body which might be able, on the one hand, successfully to oppose the formidable power of the Turks, and, on the other, to repel the incursions of the French and Germans, were the important ends which this great man proposed to accomplish. But before he engaged in these momentous undertakings, he had further personal dangers to encounter. By the instigation of Cardinal Riario, and some Florentine exiles, one Battista Frascobaldi, with only two assistants, undertook to assassinate him in the church of the Carmeli, on the festival of the ascension 1481; but the plot was discovered, the conspirators executed, and Lorenzo henceforth seldom went abroad without being surrounded by a number of tried friends.

Lorenzo was now at liberty to prosecute his benevolent purposes; and after contributing to the expulsion of the Turks from Italy, he set himself in good earnest to support the weak states against the encroachments of the more powerful. This necessarily embroiled the republic at one time with the pope, at another with the king of Naples; now with the Venetians, and then with the Duke of Milan: but when some exclaimed against him as being too precipitate in involving the republic in dangerous and expensive wars, he explained to them the necessity of maintaining the balance of power, if they would preserve the independence of their own state; and so completely had he made himself master of this subject, that he convinced the most incredulous of the propriety of his measures, which, in 1488, introduced general tranquillity into Italy.

At this period, the city of Florence was at its highest degree of prosperity. The vigilance of Lorenzo had secured it from all apprehensions of external attack; and his acknowledged disinterestedness and moderation had almost extinguished that spirit of internal dissension for which it had been so long remarkable. The Florentines gloried in their illustrious citizen, and were gratified by numbering in their body a man who wielded in his hands the fate of nations, and attracted the respect and admiration of all Europe. Medici.

Yet amidst public affairs so intricate and so momentous, such was the capacity of this man's mind, and such his versatility of genius, that, for the greater part of his life, he carried on a commerce as extensive as that of his grandfather, whilst he afforded still greater encouragement to learning and learned men. Cosmo had greatly promoted the study of the ancient languages and ancient philosophy. Lorenzo did the same thing: but he did much more; he encouraged the cultivation of his own tongue, which had been neglected since the age of Petrarca; and by setting a great example himself, he produced a race of Italian poets, which have hardly been surpassed in any age or nation. To enumerate even the names of the elegant scholars whom he patronised, would extend this article far beyond its limits. In the academy of Pisa, of which mention has been already made, the studies were chiefly confined to the Latin language, and to those sciences of which it was the principal vehicle. At Florence the Greek tongue was taught under the sanction of a public institution, either by native Greeks or learned Italians, whose services were procured by the diligence of Lorenzo de Medici, and repaid by his bounty. He placed Michael Angelo at the head of an academy, which he erected for painting and sculpture, furnishing it with the best models of antiquity. He built and endowed a public library, and sent Lascaris, of imperial descent, to Constantinople more than once, to procure Greek manuscripts. For father Moriano, the orator, a monastery was built; and Florence owed many of her finest edifices to him. Politiano and Ficino were among his most intimate friends; and it is not perhaps too much to say, that he did more for letters and science and art than any other individual that ever existed. His own acquirements in learning were great; and his poetry, of which the reader will find many specimens in the elegant work of Roscoe, was exquisite.

Is it surprising, when we examine Lorenzo's character, that all Italy, all Christendom, even the Mahometans, gave him the most flattering marks of approbation, and strove who should oblige him most, by presenting him with whatever was rare and valuable? His palace was constantly filled with men famous in every elegant, every useful science, and the neighbouring princes flocked to it as the temple of wisdom. The celebrated prince of Mirandola, on his account, chose Florence for his residence, and died there.

To a most engaging person was added each grace, and every accomplishment. He was the favourite of the ladies, the envy of the men, and the admiration of both. The statesman of his time; unrivalled in chivalry; one of the most eminent orators that the world has produced. His poetic merit, with his judgment in, and patronage of that art, procured him the title of "Father of the Muses." In liberality to his fellow citizens, as well as in every other respect, except as a general, he exceeded even Cæsar himself; and had not peace been his dear delight, his talents would have made him a consummate commander. Yet with all these superior

perior accomplifhments, he did not think it beneath him to indulge in amufements which perfons, lefs wife, would have thought an impeachment of their underftanding, and he would often feek pleafure in his nurfery, fpending hours there in all the frivolous pranks of childifh diverfion. In fine, "the gravity of his life, if compared with its levity, muft make him appear as a compofition of two different perfons, incompatible, and, as it were, impoffible to be joined with the other."

Lorenzo, like moft other great men, had wifhed to fpend his laft years in the tranquillity of retirement. He therefore at an early period wound up his mercantile concerns, and divided his time between the cares of the republic at Florence, and the cultivation of his eftates in the country. He wifhed even to diveft himfelf of all public concerns, and get his fecond fon Giovanni admitted into holy orders at the age of feven years, that he might be fit for ecclefiaftical preferment before he fhould be deprived of the protection of his father. The young ecclefiaftic, who afterwards made fuch a figure as Leo X. was accordingly appointed by Louis XI. of France, abbot of Fonte Dolac, before he was eight years of age; and by Innocent VIII. a cardinal, when he was little more than thirteen. This added much to the influence of the family, not only in the Tufcan ftates, but through all Italy; and Lorenzo having introduced his eldeft fon into public life, and accomplifhed a marriage between him and the daughter of a noble family at Rome, thought he might commit the affairs of the republic in a great meafure to Piero, and indulge his own tafte in the converfation of his learned friends. This dream of felicity however was not realized. Early in the year 1492, he was attacked by a difeafe, under which he had long laboured, with fuch violence, that on the 8th of April he died in the midft of his weeping friends, after having taken of them, one by one, an affectionate farewel, and given to his fon Piero much falutary counfel, which he thought not fit to follow.

The character of this great and good man is developed in the detail which we have given of his conduct through life: But it may not be improper to add, that fuch was the love and veneration of the citizens to him, that the phyfician, who had attended him on his deathbed, afraid to return to Florence, left the houfe in a ftate of diftraction, and plunged himfelf into a well. Throughout the reft of Italy the death of Lorenzo was regarded as a public calamity of the moft alarming kind. Of the arch which fupported the political fabric of that country he had long been confidered as the centre, and his lofs feemed to threaten the whole with immediate deftruction. When Ferdinand king of Naples was informed of the event, he exclaimed, "This man has lived long enough for his own glory, but too fhort a time for Italy."

MEDICINA FORENSIS, is a phrafe ufed in Germany to denote thofe parts of anatomical and phyfiological knowledge, which enable phyficians and furgeons to decide certain caufes as judges in courts of juftice. In that country it has long been law and cuftom (if we miftake not, by the Caraline code of Charles V.) to refer cafes of *poifoning*, *child-murder*, *rape*, *pregnancy*, *impotency*, *ideotifm*, &c. to the medical faculty, which, in the univerfities and fome other great towns, is conftituted into a kind of court for the trial of fuch queftions. In this country there are no fuch courts; but in criminal trials medical gentlemen are often called upon to defcribe the fymptoms of *poifoning*, *child-murder*, *rape*, &c. and therefore it becomes them to obtain an accurate knowledge of thefe fymptoms, and to ftore their memories with a number of minute facts, to which they may have occafion to appeal when giving their evidence.

The importance of this fubject induced the profeffor of the inftitutes of phyfic in the univerfity of Edinburgh to refolve lately to read an annual courfe of lectures on MEDICAL JURISPRUDENCE. This, we doubt not, will prove a valuable courfe; for though it is hardly conceivable that, under the head *medical jurifprudence*, any *knowledge* can be communicated which a well-educated phyfician would not neceffarily have acquired, without attending fuch a courfe; yet it is very obvious, that the recollection of the young phyfician may receive great aid from his liftening to the well arranged lectures of an accurate profeffor. From thefe lectures he may ftore his mind with a collection of aphorifms which fhall be always ready on the day of examination; or the lectures themfelves may be delivered in queftions and anfwers with all the formalities of a criminal court.

We have heard it obferved, that to attend a courfe of fuch lectures would be of the utmoft advantage to all who may be called upon to ferve as jurymen in criminal trials; but of the truth of this obfervation we are more than doubtful. Perfons who are only *half* inftructed are always conceited of their own attainments; and men not acquainted with anatomy and phyfiology cannot be *more* than half inftructed by the ableft courfe poffible to be given of medical jurifprudence. Such perfons indeed can hardly avoid miftaking the fenfe of the profeffor's language, however perfpicuous that language may be. Of this we had lately a very ftriking inftance. A gentleman, by no means illiterate, though a ftranger to anatomical and phyfiological fcience, was expatiating to the writer of this article upon the general importance of medical jurifprudence, a courfe of which, he faid, he had attended for the fole purpofe of qualifying himfelf for difcharging the important duties of a juryman. Upon being afked what he had learned? he replied, that he had been taught, among other things which we thought frivolous, to difcern, from the fymptoms of *hanging* whether the dead man had been hanged by *himfelf* or by *another*. We need not furely obferve, that no fuch leffon was ever taught in any univerfity, or by any medical lecturer; but it is worthy of confideration whether lectures on medical jurifprudence may not have the moft pernicious effects on the minds of men fo little qualified as this gentleman to profit by them. To the regularly educated phyfician and furgeon fuch lectures may prove ufeful; to the plain citizen, not fkilled in anatomy and phyfiology, they muft prove dangerous; as their only tendency is to make him defpife the evidence given before him by the regular phyfician or furgeon; to place implicit confidence in his own fuperficial knowledge; and thus to decide at random on the life or death of his fellow-creature:

> A little learning is a dangerous thing;
> Drink deep, or tafte not the Pierian fpring.

MEDINA, the capital of the kingdom of Woolli in Africa, is fituated in 13° 40′ N. Lat. and 12° 40′ W. Long. It is a place of confiderable extent, and may contain from 800 to 1000 houfes. It is fortified in the common

Medusa, Megameter.

common African manner, by a surrounding high wall built of clay, and an outward fence of pointed stakes and prickly bushes; but the walls are neglected, and the outward fence has suffered considerably from the active hands of busy housewives, who pluck up the stakes for firewood. Mr Park passed through it on his route eastward, and was treated with much kindness both by the king and the people. The good old sovereign warned him of the dangers he was about to encounter, and endeavoured to persuade him to relinquish all thoughts of his journey eastward; but when he could not prevail, he gave him a guide, who conducted him in safety to Koojar, the frontier town of the kingdom towards Bondou, from which it is separated by an intervening wilderness of two days journey. Here our author was presented, by way of refreshment, with a liquor which tasted so much like the strong beer of his native country (and very good beer too), as to induce him to inquire into its composition; and he learned, with some degree of surprise, that it was actually made from corn which had been previously malted, much in the same manner as barley is malted in Great Britain: a root yielding a grateful bitter was used in lieu of hops, the name of which he forgot; but the corn which yields the wort is the *holcus spicatus* of botanists.

MEDUSA. In addition to the different species of this genus of vermes described in the *Encyclopædia*, that which is represented in two different attitudes, fig. 1. and 2. and which strongly resembles a bagpipe in shape, may be worthy of notice. It is merely a white transparent vesicle, furnished with several blue tentacles yellowish at their extremity; its long tail, which is also blue, appears to be composed of a number of small glandulous grains, flattened and united together by a gelatinous membrane. The upper part of the vesicle exhibits a kind of seam with alternate punctures of three different sizes; its elongated part, which may be considered as the head of the animal, is terminated by a single trunk, the exterior edge of which is fringed with 25 or 26 tentacles, much smaller than those which originate from the insertion of its long tail, and the number of which sometimes amounts to 30. By means of these last, the diameter of which it is capable of increasing at pleasure by forcing in a little of the air from its body, it fixed itself to the side of the vessel, in which it was placed, in such a manner as that the extremity of some of its tentacles occupied a surface of two or three lines from its body. The most moveable part of the vesicle is its elongation, or the head of the animal, as it is by means of this that it performs its different motions. The rounded substance, marked by the letter P, is situated in the centre of the larger tentacles, which are firmly fixed to the body of the animal near its tail; and is only an assemblage of a few minute gelatinous globules, from the middle of which arise other larger globules, with a small peduncle, about the middle of which is fixed a curved bluish coloured body, which is represented magnified in two positions at R. Martiniere, the naturalist, who accompanied Perouse in his voyage round the world, met with this animal in about the 20th degree of lat. and 179° of long. east from Paris.

Plate XXXVI.

MEGAMETER, a name sometimes given to the MICROMETER, which see, *Encycl.*

Mehall, Meninski.

MEHALL, in the language of Bengal, a place or district.

MENINSKI (Franciscus), a most celebrated German orientalist, was born in Lorraine, then subject to the emperor, in the year 1623; and for copiousness of learning, elegance of genius, and profound knowledge of languages, particularly those of the East, proved undoubtedly one of the principal ornaments of the age in which he lived. He studied at Rome under Giattino. When he was about 30, his love of letters induced him to accompany the Polish ambassador to Constantinople, where he studied the Turkish language under Bobovius and Ahmed, two very skilful teachers. So successful was he in this study, that when he had been there only two years, the place of first interpreter to the Polish embassy at the Porte was promised to him. When the place became vacant, he was accordingly appointed to it, and obtained so much credit by his conduct, that, after a time, he was sent for into Poland, and again sent out with full powers as ambassador to the Porte. For his able execution of this office, he was further honoured, by being naturalized in Poland; on which occasion he added the Polish termination of *ski* to his family name, which was Menin. Being desirous afterwards to extend his sphere of action, he went to the court of the emperor as interpreter of oriental languages in 1661. Here also, as in other instances, his talents and behaviour obtained the highest approbation; on which account he was not only sent as interpreter to several imperial ambassadors at the Porte, but was intrusted in many important and confidential services; and, in 1669, having paid a visit to the holy sepulchre at Jerusalem, was made one of the knights of that order. After his return to Vienna he was advanced to further honours; being made one of the counsellors of war to the emperor, and first interpreter of oriental languages. At Vienna he died at the age of 75, in the year 1698. His great work, 1. The "Thesaurus linguarum orientalium," was published at Vienna in 1680, in 4 vols folio; to which was added, in 1687, another volume, intitled, "Complementum Thesauri linguarum orientalium, seu onomasticum Latino-Turcico-Arabico-Persicum." The former volumes having become extremely scarce, partly on account of the destruction of a great part of the impression, in the siege of Vienna by the Turks in 1683, a design was formed some time ago in England of reprinting the work, by a society of learned men, among whom was Sir William Jones. But as this undertaking, probably on account of the vast expence which must have been incurred, did not proceed, the empress queen Maria Theresa, who had heard of the plan, took it upon herself, and with vast liberality furnished every thing necessary for its completion. In consequence of this, it was begun to be splendidly republished at Vienna in 1780, with this title: "Francisci a Mesgnien Meninski Lexicon Arabico-Persico-Turcicum, adjecta ad singulas voces et Phrases interpretatione Latina, ad usitatiores, etiam Italica." Of this edition only two vols folio are yet published, extending no farther than *zal*, the ninth letter of the Arabic alphabet, which is about a third of the whole. The delay of the rest is much to be lamented. In this addition, say the editors, the Lexicon of Meninski may be said to be increased, diminished, and amended. *Increased*, because many Arabic and Persian words

Meninſki, Merchetta. words are added, from Wankuli and Ferhengi, the beſt Arabic and Perſic lexicographers whom the Eaſt has produced; and from Herbelot are inſerted the names of kingdoms, cities, and rivers, as well as phraſes in common uſe among the Turks, &c. *Diminiſhed*, becauſe many uſeleſs ſynonyma are omitted, which rather puzzled than aſſiſted the ſtudent; as well as all the French, Poliſh, and German interpretations, the Latin being conſidered as ſufficient for all men of learning. *Amended*, with reſpect to innumerable typographical errors; which, however, from a work of this nature, no care can perhaps altogether exclude. The other works of Meninſki were occaſioned chiefly by a violent conteſt between him and a man named J. B. Podeſta, in which much acrimony was employed on both ſides. Theſe it is hardly worth while to enumerate, but they may all be ſeen in the account of his life from which this article is taken (A). It ſhould be obſerved, however, that in 1674, Podeſta publiſhed a book, intitled, "Prodromus novi linguarum orientalium collegii, juſſu Aug. &c. erigendi, in Univ. Viennenſi;" to which Meninſki oppoſed, 2. "Meninſkii Antidotum in Prodromum novi ling. orient. collegii, &c." 4to. But ſuch was the credit of his antagoniſt in the univerſity, that ſoon after there came out a decree in the name of the rector and conſiſtory, in which that antidote of Meninſki's is proſcribed and prohibited, for ſix ſpecific reaſons, as impious and infamous. Meninſki was defended againſt this formidable attack by a friend, in a ſmall tract, intitled, "Veritas defenſa, ſeu juſtitia cauſæ Dn. F. de M. M. [Meninſki] contra infame decretum Univerſitatis Viennenſis, Anno 1674, 23 Novembris, &c. ab Amico luci expoſita, Anno 1675," in which this friend expoſes, article by article, the falſehood of the decree, and exclaims ſtrongly againſt the arts of Podeſta. This tract is in the Britiſh Muſeum. Podeſta was oriental ſecretary to the emperor, and profeſſor of thoſe languages at Vienna; but is deſcribed in a very ſatirical manner by the defender of Meninſki. "Podeſta, natura Semi-Italus, ſtatura nanus, cæcutiens, balbus, imo bardus repertus, aliiſque vitiis ac ſtultitiis plenus, adeoque ad diſcendas linguas orientales inhabilis." A liſt of the works of Podeſta is, however, given by the late editors of Meninſki.

MERCHETTA, or *Marchetta Mulierum*, is commonly ſuppoſed to have been a right which, during the prevalence of the feudal ſyſtem, the lord had of paſſing the firſt night after marriage with his female villain. This opinion has been held by the greater part of our antiquarians; and we have adopted it in our hiſtory of Scotland publiſhed in the *Encyclopædia*. It appears, however, to be a miſtake. That there was a cuſtom called *merchetta mulierum*, which prevailed not only in England, Scotland, Wales, and the iſle of Guernſey, but alſo on the continent, is indeed a fact unqueſtionable; but Mr Aſtle has clearly proved, that, inſtead of being an adulterous connection, the *merchetta* was a compact between the lord and his vaſſal for the redemption of an *offence* committed by that vaſſal's *unmarried* daughter. He admits, however, that it denoted likewiſe a fine paid by a *ſokeman* or a *villain* to his lord for a licence to marry his daughter to a free man; and that if the vaſſal gave her away without obtaining ſuch a licence, he was liable to pay a heavier fine. He quotes two authorities in ſupport of his opinion from Bracton; one of which we ſhall tranſcribe, as being alone complete evidence.

Archæologia, vol. xii.

"Ric. Burre tenet unum meſuagium et debet telliagium ſectam curiæ, et *merchet*, hoc modo, *quod ſi maritare voluerit filiam ſuam cum quodam libero homine, extra villam, faciet pacem domini pro maritagio, et ſi eam maritaverit alicui cuſtumario villæ, nihil debuit pro maritagio.*"

"The probable reaſon of the cuſtom (ſays Mr Aſtle) appears to have been this. Perſons of low rank, reſiding on an eſtate, were either *aſcripti glebæ*, or were ſubjected to ſome ſpecies of ſervitude ſimilar to the *aſcripti glebæ*. They were bound to reſide on the eſtate, and to perform ſeveral ſervices to the lord. As women neceſſarily followed the reſidence of their huſbands, the conſequence was, that when a woman of low rank married a ſtranger, the lord was deprived of part of his live ſtock; he therefore required a fine to indemnify him for the loſs of his property," Further particulars on the *merchetta* are to be found in the Appendix to vol. 1ſt of *Sir David Dalrymple's Annals of Scotland.*

Meridian. MERIDIAN Line, an arch or part of the meridian of the place, terminated each way by the horizon. Or, a meridian line is the interſection of the plane of the meridian of the place with the plane of the horizon, often called a north and ſouth line, becauſe its direction is from north to ſouth.

In the article Astronomy (*Encycl.*), n° 376. and 377. we have given two methods of drawing a meridian line; but it may be proper to add, in this place, the following improvement of the former of theſe from Dr Hutton's Mathematical Dictionary. "As it is not eaſy (ſays the Doctor) to determine preciſely the extremity of the ſhadow, it will be beſt to make the ſtile flat at the top, and to drill a ſmall hole through it, noting the lucid point projected by it on the ſeveral concentric circles, inſtead of marking the extremity of the ſhadow itſelf on theſe circles."

We ſhall give another method of drawing a meridian line from the ſame valuable dictionary.

"Knowing the ſouth quarter pretty nearly, obſerve the altitude FE of ſome ſtars on the eaſt ſide of it, and not far from the meridian HZRN: then, keeping the quadrant firm on its axis, ſo as the plummet may ſtill cut the ſame degree, direct it to the weſtern ſide of the meridian, and wait till you find the ſtar has the ſame altitude as before, as *fe*. Laſtly, biſect the angle EC*e*, formed by the interſection of the two planes in which the quadrant has been placed at the time of the two obſervations, by the right line HR, which will be the meridian ſought.

Plate XXXVI.

Magnetical Meridian, is a great circle paſſing thro' or by the magnetical poles; to which meridians the magnetical needle conforms itſelf. See Magnetism, *Suppl.*

MESO-

(A) We have taken this article from the Biographical Dictionary; the editors of which took it from the life of Meninſki prefixed to the new edition of his great work.

MESO-LOGARITHM, a term used by Kepler to signify the logarithms of the cosines and cotangents.

MESURATA, a sea port of the kingdom of Tripoli, in Africa. A caravan proceeds from this place to Fezzan, and other interior parts toward the south of Africa. It is 260 miles north of Mourzook. E. Lon. 15. 5. N. Lat. 31. 3.

METALLIC TRACTORS. See PERKINISM in this *Suppl.*

METONIC CYCLE, called also the *Golden Number*, and *Lunar Cycle*, or *Cycle of the Moon*, that which was invented by Meton the Athenian; being a period of 19 years. See CYCLE, *Encycl.*

MHA RAJAH, the highest title of Hindoos.

MICROCOUSTICS, or MICROPHANES, instruments contrived to magnify small sounds, as microscopes do small objects.

MICROCOSMIC SALT. See CHEMISTRY-*Index*, *Suppl.*

MIDDLE LATITUDE, is half the sum of two given latitudes; or the arithmetical mean, or the middle between two parallels of latitude. Therefore,

If the latitudes be of the same name, either both north or both south, add the one number to the other, and divide the sum by 2; the quotient is the middle latitude, which is of the same name with the two given latitudes. But,

If the latitudes be of different names, the one north and the other south; subtract the less from the greater, and divide the remainder by 2, so shall the quotient be the middle latitude, of the same name with the greater of the two.

MIDSUMMER-DAY, is held on the 24th of June, the same day as the nativity of St John the Baptist is held.

MILK, or MILKYET, property in Bengal.

MILLS of various kinds are described in the article MECHANICS (*Encycl.*); and he who shall study that article, together with *Water-Works*, and MACHINERY, in this *Supplement*, will have a sufficient knowledge of the principles upon which mills must be constructed, so as that they may produce their proper effects. The subject is introduced into this place merely to put it into the power of our countrymen to adopt, if they shall think fit, the improvements which have been made in the machinery of flour mills in America.

The chief of these consist in a new application of the screw, and the introduction of what are called elevators, the idea of which was evidently borrowed from the chain-pump. The screw is made by sticking small thin pieces of board, about three inches long and two wide, into a cylinder, so as to form the spiral line. This screw is placed in a horizontal position, and by turning on its axis it forces wheat or flour from one end of a trough to the other. For instance, in the trough which receives the meal immediately coming from the stones, a screw of this kind is placed, by which the meal is forced on, to the distance of six or eight feet, perhaps, into a reservoir; from thence, without any manual labour, it is conveyed to the very top of the mill by the elevators, which consist of a number of small buckets of the size of tea cups, attached to a long band that goes round a wheel at the top, and another at the bottom of the mill. As the band revolves round the wheels, these buckets dip into the reservoir of wheat or flour below, and take their loads up to the top, where they empty themselves as they turn round the upper wheel. The elevators are inclosed in square wooden tubes, to prevent them from catching in any thing, and also to prevent dust. By means of these two simple contrivances, no manual labour is required from the moment the wheat is taken to the mill till it is converted into flour, and ready to be packed, during the various processes of screening, grinding, sifting, &c.

That this is a considerable improvement is obvious; and we are not without hopes that it may be adopted. The licentiousness of an English mob has indeed persecuted an Arkwright, expelled the inventor of the fly-shuttle from his native country, and by such conduct prevented the re-erection of the Albion mills, and the general establishment of saw-mills through the kingdom; but their sovereignty perhaps will not be roused by so easy and simple a contrivance as this to lessen the quantity of manual labour. For an account of the Dutch oil-mill, which was somehow omitted in its proper place in the *Encyclopædia*, see *OIL-Mill* in this *Supplement*.

MINERALOGY

1 Definition. IS a science, the object of which is the description and arrangement of *inorganic bodies* or *minerals*; or of *all* the bodies which belong to our globe, excepting *animal* and *vegetable* substances.

Since the publication of the article MINERALOGY, *Encycl.* scarcely a single day has passed without the discovery of some new mineralogical fact, or the detection of some old and unsuspected error. These improvements cannot be overlooked in the present *Supplement*. But they are so numerous in every part of the science, that we can hardly notice them without giving a pretty complete view of the present state of mineralogy. This will scarcely occupy more room, and must be much more useful as well as entertaining, than an undigested mass of annotations and remarks. We undertake this task the more readily, because in the article MINERALOGY in the *Encyclopædia*, the improvements of Mr Werner and his disciples, to which the science is indebted for a great part of its present accuracy, have been entirely overlooked.

The object of mineralogy is twofold. 1. To *describe* every mineral with so much accuracy and precision, that it may be easily distinguished from every other mineral. 2. To *arrange* them into a system in such a manner that every mineral may be easily referred to its proper place, and that a person may be able, merely by the help of the system, to discover the *name* of any mineral whatever. When these two objects are accomplished, mineralogy, 2 Object.

Deſcription of Minerals.

neralogy, ſtrictly ſo called, is completed. But were we to ſtop here, the utility of the ſcience, if it would be entitled to the name of ſcience, could hardly be conſidered as very great. We muſt therefore apply *chemiſtry* to diſcover the ingredients of which minerals are compoſed, and to detect, if poſſible, the laws which theſe ingredients have obſerved in their combination. Thus we ſhall really extend our knowledge of inorganic nature, and be enabled to apply that knowledge to the improvement of almoſt eve y art and manufacture.

3 Diviſion of the article.

Mineralogy naturally divides itſelf into three parts. The *firſt* treats of the method of deſcribing minerals; the *ſecond*, of the method of arranging them; and the *third* exhibits them in a ſyſtem deſcribed and arranged according to the rules laid down in the two firſt parts. Theſe three parts ſhall be the ſubjects of the following chapters; and we ſhall finiſh the article with a chapter on the chemical analyſis of minerals.

Chap. I. Of the Description of Minerals.

Nothing, at firſt ſight, appears eaſier than to deſcribe a mineral, and yet, in reality, it is attended with a great deal of difficulty. The mineralogical deſcriptions of the ancients are ſo looſe and inaccurate, that many of the minerals to which they allude cannot be aſcertained; and conſequently their obſervations, however valuable in themſelves, are often, as far as reſpects us, altogether loſt. It is obvious, that to diſtinguiſh a mineral from every other, we muſt either mention ſome peculiar property, or a collection of properties, which exiſt together in no other mineral. Theſe properties muſt be deſcribed in terms rigidly accurate, which convey preciſe ideas of the very properties intended, and of no other properties. The ſmalleſt deviation from this would lead to confuſion and uncertainty. Now it is impoſſible to deſcribe minerals in this manner, unleſs there be a peculiar term for each of their properties; and unleſs this term be completely underſtood. Mineralogy therefore muſt have a language of its own; that is to ſay, it muſt have a *term* to denote every mineralogical property, and each of theſe terms muſt be accurately defined. The language of mineralogy was invented by the celebrated Werner of Freyberg, and firſt made known to the world by the publication of his treatiſe on *The External Characters of Minerals*. Of this language we ſhall give a view in the following general deſcription of the properties of minerals (A).

4 Properties of minerals.

The properties of minerals may be divided into two claſſes. *1ſt*, Properties diſcoverable without deſtroying the texture of the mineral; *2d*, Properties reſulting from the action of other bodies on it. The firſt claſs has, by Werner and his diſciples, been called *external* properties, and by ſome French writers *phyſical*; the ſecond claſs has been called *chemical*.

The *external* properties may be arranged under the following heads:

External Characters.

1. Figure,	8. Ductility,	14. Sound,
2. Surface,	9. Fracture,	15. Smell,
3. Tranſparency,	10. Texture,	16. Taſte,
4. Colour,	11. Structure,	17. Gravity,
5. Scratch,	12. Fragments,	18. Magnetiſm,
6. Luſtre,	13. Feel,	19. Electricity.
7. Hardneſs,		

5 Figure.

I. By figure is meant the ſhape or form which a mineral is obſerved to have. The *figure* of minerals is either *regular*, *particular*, or *amorphous*. 1. Minerals which aſſume a regular figure are ſaid to be cryſtallized *. The *ſides* of a cryſtal are called *faces*; the ſharp line formed by the inclination of two faces is called an *edge*; and the corner, or angle, formed by the meeting of ſeveral edges in one point, is called a *ſolid angle*, or ſimply *an angle*. Thus a cube has ſix faces, twelve edges, and eight angles. 2. Some minerals, though not cryſtallized, affect a *particular* figure. Theſe particular figures are the following: *Globular*, like a globe; *oval*, like an oblong ſpheroid; *ovate*, like an egg; *cheeſe-ſhaped*, a very flattened ſphere; *almond-ſhaped*, like an almond; *lenticular*, like a double convex lenſe, compreſſed and gradually thinner towards the edges; *cuneiform*, like a wedge; *nodulous*, having depreſſions and protuberances like a potatoe; *botryoidal*, like grapes cloſely preſſed together; *dentiform*, longiſh and tortuous, and thicker at the bottom than the top; *wireform*, like a wire; *capillary*, like hair, finer than the preceding; *retiform*, threads interwoven like a net; *dentritic*, like a tree, having branches iſſuing from a common ſtem; *ſhrubform*, branches not ariſing from a common ſtem; *coraloidal*, branched like coral; *ſtalactical*, like iſicles; *clavated*, like a club, long, and thicker at one end than another; *faſciform*, long ſtraight cylindrical bodies, united like a bundle of rods; *tubular*, cylindrical and hollow. 3. When minerals have neither a regular nor particular ſhape, they are ſaid to be *amorphous*.

* See Chemistry, Part III. ch. iv. *Suppl.*

6 Surface.

II. By surface is meant the appearance of the external ſurface of minerals. The *ſurface* is either *uneven*, compoſed of ſmall unequal elevations and depreſſions; *ſcabrous*, having very ſmall *ſharp* and rough elevations, more eaſily felt than ſeen; *druſy*, covered with very minute cryſtals; *rough*, compoſed of very minute *blunt* elevations, eaſily diſtinguiſhable by the feel; *ſcaly*, compoſed of very minute thin ſcale-like leaves; *ſmooth*, free from all inequality or roughneſs; *ſpecular*, having a ſmooth poliſhed ſurface like a mirror; or *ſtreaked*, having elevated, ſtraight, and parallel lines. This laſt character is confined to the *ſurface* of cryſtals. The *ſtreaks* are either *tranſverſe*; *longitudinal*; *alternate*, in different directions on different faces; *plumoſe*, running from a middle rib; or *decuſſated*, croſſing each other.

7 Tranſparency.

III. By transparency is meant the proportion of light which minerals are capable of tranſmitting. They are *tranſparent* or *pellucid* when objects can be ſeen diſtinctly through them; *diaphanous*, when objects are ſeen

(A) The fulleſt account of Werner's external characters which we have ſeen in the Engliſh language, has been given by Dr Townſon in his *Philoſophy of Mineralogy*. We have availed ourſelves of this book, in order to exhibit ſome of the lateſt improvements of Werner and his diſciples. The reader may alſo conſult *Werner's Treatiſe*, publiſhed at Leipſic in 1774; or the *French tranſlation* publiſhed at Dijon in 1790. See alſo *Romé de Liſle. Des Caracters Exterieur des Mineraux.* And *Hauy Jour. d'Hiſt. Nat.* II. 56.

External Characters. ſeen through them indiſtinctly; *ſubdiaphanous*, when light paſſes but in ſo ſmall a quantity that objects cannot be ſeen through them (B); *opaque*, when no light is tranſmitted.

When opaque minerals become tranſparent in water, they are called *hydrophanous*. When objects are ſeen double through a tranſparent mineral, it is ſaid to *refract doubly*.

8 Colour. IV. The colours of minerals may be reduced to eight claſſes.

1. *Whites.*

Snow white. Pure white.

Reddiſh white. White with a light tint of red.

Yellowiſh white. White with a light tint of yellow.

Silver white. Yellowiſh white with a metallic luſtre.

Greyiſh white. White with a light tint of black.

Greeniſh white. White with a light tint of green.

Milk white. White with a light tint of blue.

Tin white. Milk white of a metallic luſtre.

2. *Greys.*

Bluiſh grey. Grey with a little blue.

Lead grey. Bluiſh grey with a metallic luſtre.

Pearl grey. Light grey with a ſlight mixture of violet blue.

Smoke grey. Dark grey with a little blue and brown.

Greeniſh grey. Light grey tinged with green.

Yellowiſh grey. A light grey tinged with yellow.

Steel grey. A dark grey with a light tint of yellow and a metallic luſtre.

Black grey. The darkeſt grey with a tint of yellow.

3. *Blacks.*

Greyiſh black. Black with a little white.

Browniſh black. Black with a tint of brown.

Black. Pure black.

Iron black. Pure black with a ſmall mixture of white and a metallic luſtre.

Bluiſh black. Black with a tint of blue.

4. *Blues.*

Indigo blue. A dark blackiſh blue.

Pruſſian blue. The pureſt blue.

Azure blue. A bright blue with ſcarce a tint of red.

Smalt blue. A light blue.

Violet blue. A mixture of azure blue and carmine.

Lavender blue Violet blue mixed with grey.

Sky blue. A light blue with a ſlight tint of green.

5 *Greens.*

Verdigris green. A bright green of a bluiſh caſt.

Seagreen. A very light green, a mixture of verdigris green and grey.

Beryl green. The preceding, but of a yellowiſh caſt.

Emerald green. Pure green.

Graſs green. Pure green with a tint of yellow.

Apple green. A light green formed of verdigris green and white.

Leek green. A very dark green with a caſt of brown.

Blackiſh green. The darkeſt green, a mixture of leek green and black.

Piſtachio green. Graſs green, yellow and a little brown

Olive green. A pale yellowiſh green with a tint of brown.

Aſparagus green. The lighteſt green, yellowiſh with a little brown and grey.

6. *Yellows.*

Sulphur yellow. A light greeniſh yellow.

Braſs yellow. The preceding, with a little leſs green and a metallic luſtre.

Lemon yellow. Pure yellow.

Gold yellow. The preceding with a metallic luſtre.

Honey yellow. A deep yellow with a little reddiſh brown.

Wax yellow. The preceding, but deeper.

Pyritaceous. A pale yellow with grey.

Straw yellow. A pale yellow, a mixture of ſulphur yellow and reddiſh grey.

Wine yellow. A pale yellow with a tint of red.

Ochre yellow. Darker than the preceding, a mixture of lemon yellow with a little brown.

Iſabella yellow. A pale browniſh yellow, a mixture of pale orange with reddiſh brown.

Orange yellow. A bright reddiſh yellow, formed of lemon yellow and red.

7. *Reds.*

Aurora red. A bright yellow red, a mixture of ſcarlet and lemon yellow.

Hyacinth red. A high red like the preceding, but with a ſhade of brown.

Brick red. Lighter than the preceding; a mixture of aurora red and a little brown.

Scarlet red. A bright and high red with ſcarce a tint of yellow.

Copper red. A light yellowiſh red with the metallic luſtre.

Blood red. A deep red, a mixture of crimſon and ſcarlet.

Carmine red. Pure red verging towards a caſt of blue.

Cochineal red. A deep red; a mixture of carmine with a little blue and a very little grey.

Crimſon red. A deep red with a tint of blue.

Fleſh red. A very pale red of the crimſon kind.

Roſe red. A pale red of the cochineal kind.

Peach bloſſom red. A very pale whitiſh red of the crimſon kind.

Mordoré. A dark dirty crimſon red; a mixture of crimſon and a little brown.

Browniſh red. A mixture of blood red and brown.

8. *Browns.*

Reddiſh brown. A deep brown inclining to red.

Clove brown. A deep brown with a tint of carmine.

Yellowiſh brown. A light brown verging towards ochre yellow.

Umber brown. A light brown, a mixture of yellowiſh brown and grey.

Hair brown. Intermediate between yellow brown and clove brown with a tint of grey.

Tombac brown. A light yellowiſh brown, of a metallic luſtre, formed of gold yellow and reddiſh brown.

Liver

(B) After Mr Kirwan, we have denoted theſe three degrees of tranſparency by the figures 4, 3, 2. When a mineral is ſubdiaphanous only at the edges, that is denoted by the figure 1. Opacity is ſometimes denoted by 0.

External Characters. Liver brown. A dark brown; blackiſh brown with a tint of green.

Blackiſh brown. The darkeſt brown.

Colours, in reſpect of intenſity, are either *dark*, *deep*, *light*, or *pale*. When a colour cannot be referred to any of the preceding, but is a mixture of two, this is expreſſed, by ſaying, that the prevailing one *verges* towards the other, if it has only a ſmall tint of it; *paſſes* into it, if it has a greater.

9 Streak. V. By the SCRATCH or STREAK, is meant the mark left when a mineral is ſcratched by any hard body, as the point of a knife. It is either *ſimilar*, of the ſame colour with the mineral; or *diſſimilar*, of a different colour.

10 Luſtre. VI. LUSTRE, is the gloſs, or brightneſs which appears on the external ſurface of a mineral, or on its internal ſurface when freſh broken. The firſt is called *external*, the ſecond *internal* luſtre. Luſtre is either *common*, that which moſt minerals poſſeſs; *ſilky*, like that of ſilk or mother-of-pearl; *waxy*, like that of wax; *greaſy*, like that of greaſe; or *metallic*, like that of metals.

As to the degree, the greateſt is called *ſplendent*, the next *ſhining*, the third *dulliſh*; and when only a few ſcattered particles ſhine, the luſtre is called *dull* (c).

11 Hardneſs. VII. We have uſed figures to denote the comparative HARDNESS of bodies; for an explanation of which, we refer to the article CHEMISTRY, Vol. I. p 226. of this *Supplement*.

12 Ductility and brittleneſs. VIII. With reſpect to DUCTILITY and BRITTLENESS, minerals are either *malleable*; *ſectile*, capable of being cut without breaking, but not malleable; *flexile*, capable of being bent, and when bent retaining their ſhape; or *elaſtic*, capable of being bent, but recovering their former ſhape. Minerals deſtitute of theſe properties are *brittle*. Brittle minerals, with reſpect to the eaſe with which they may be broken, are either *very tough*, *tough*, *fragile*, or *very fragile*.

13 Fracture. IX. By FRACTURE is meant the freſh ſurface which a mineral diſplays when broken. It is either *flat*, without any general elevation or depreſſion; or *conchoidal*, having wide extended roundiſh hollows and gentle riſings. When theſe are not *very* evident, the fracture is called *flat* conchoidal; when they are ſmall, it is called *ſmall* conchoidal; and when of great extent, *great* conchoidal.

The fracture may alſo be *even*, free from all aſperities; *uneven*, having many ſmall, ſharp, abrupt, irregular elevations and inequalities; and from the ſize of theſe, this fracture is denominated *coarſe*, *ſmall*, or *fine*; *ſplintery*, having ſmall, thin, half detached, ſharp edged ſplinters, according to the ſize of which this fracture is denominated *coarſe* or *fine*; or *rugged*, having many very minute ſharp hooks, more ſenſible to the hand than the eye.

14 Texture. X. By TEXTURE is meant the internal ſtructure or diſpoſition of the matter of which a mineral is compoſed, which may be diſcovered by breaking it. The texture is either *compact*, without any diſtinguiſhable parts, or the appearance of being compoſed of ſmaller parts; *earthy*, compoſed of very minute *almoſt* imperceptible rough parts; *granular*, compoſed of ſmall ſhapeleſs grains; *globuliform*, compoſed of ſmall ſpherical bodies; *fibrous*, compoſed of fibres which may be *long*, *ſhort*, *ſtraight*, *crooked*, *parallel*, *divergent*, *ſtellated*, *faſciculated*, or *decuſſated*; *radiated*, conſiſting of long narrow flattiſh lamellæ; or *lamellar* or *foliated*, conſiſting of ſmooth continued plates covering each other; theſe plates may be either *ſtraight*, *crooked*, or *undulating*. External Characters.

XI. The STRUCTURE or COMPOUND TEXTURE is the manner in which the parts that form the texture are diſpoſed. It is either *ſlaty*, in ſtraight layers like ſlate; *teſtaceous*, in incurvated layers; *concentric*, in concentric layers; or *columnar*, in columns. 15 Structure

The *texture* and *ſtructure* may at firſt view appear the ſame; but in reality they are very different. Thus common ſlate has often the *ſlaty ſtructure* and *earthy texture*. The texture of pitcoal is compact, but its ſtructure is often ſlaty.

XII. By FRAGMENTS is meant the ſhape of the pieces into which a mineral breaks when ſtruck with a hammer. They are either *cubic*; *rhomboidal*; *wedgeſhaped*; *ſplintery*, thin, long, and pointed; *tabular*, thin, and broad, and ſharp at the corners, as common ſlate; or *indeterminate*, without any particular reſemblance to any other body. The *edges* of indeterminate fragments are either *very ſharp*, *ſharp*, *ſharpiſh*, or *blunt*. 16 Fragments.

XIII. By the FEEL of minerals is meant the ſenſation which their ſurfaces communicate when handled. The feel of ſome minerals is *greaſy*, of others, *dry*, &c. 17 Feel.

XIV. Some minerals when ſtruck give a *clear* SOUND, as common ſlate; others a *dull* ſound. 18 Sound.

The SMELL, TASTE, SPECIFIC GRAVITY, and MAGNETISM of minerals, require no explanation.

With reſpect to ELECTRICITY, ſome minerals become electric when *heated*, others when *rubbed*, others cannot be rendered electric. The electricity of ſome minerals is *poſitive* or *vitreous*, of others *negative* or *reſinous*.

As for the CHEMICAL properties of minerals, they have been already explained in the article CHEMISTRY, which makes a part of this *Supplement*. And for the deſcription of the blow-pipe, and the manner of uſing it, we refer the reader to a treatiſe on that ſubject prefixed to the article MINERALOGY in the *Encyclopædia*.

CHAP. II. OF THE ARRANGEMENT OF MINERALS.

MINERALS may be arranged two ways, according to their external characters, and according to their chemical compoſition. The firſt of theſe methods has been called an *artificial* claſſification; the ſecond, a *natural* one. The firſt is indiſpenſably neceſſary for the ſtudent of nature; the ſecond is no leſs indiſpenſable for the proficient who means to turn his knowledge to account. Without the firſt, it is impoſſible to diſcover the *names* of minerals; and without the ſecond, we muſt remain ignorant of their uſe.

Almoſt every ſyſtem of mineralogy hitherto publiſhed, at leaſt ſince the appearance of Werner's *external characters*, has attempted to combine theſe two arrangements, and to obtain at one and the ſame time the advantages peculiar to each. But no attempt of this kind has hitherto ſucceeded. Whether this be owing to any thing impoſſible in the undertaking, or to the preſent

(c) Theſe four degrees have been denoted by Kirwan by the figures 4, 3, 2, 1, and no luſtre by 0. We have imitated him in the preſent article.

Artificial Syſtem.

preſent imperfect ſtate of mineralogy, as is more probable, we do not take upon us to determine. But ſurely the want of ſucceſs, which has hitherto attended all attempts to combine the two arrangements, ought to ſuggeſt the propriety of ſeparating them. By adhering ſtrictly to one language, the trouble of ſtudying two different ſyſtems would be entirely prevented. They would throw mutual light upon each other; the artificial ſyſtem would enable the ſtudent to diſcover the *names* of minerals; the natural would enable him to arrange them, and to ſtudy their properties and uſes.

The happy arrangement of Cronſtedt, together with the ſubſequent improvements of Bergman, Werner, Kirwan, Hauy, and other celebrated mineralogiſts, has brought the *natural* ſyſtem of mineralogy to a conſiderable degree of perfection. But an *artificial* ſyſtem is ſtill a deſideratum; for excepting Linnæus, whoſe ſucceſs was precluded by the ſtate of the ſcience, no one has hitherto attempted it. Though we are very far from thinking ourſelves ſufficiently qualified for undertaking ſuck a taſk, we ſhall neverthelefs venture, in the next chapter, to ſketch out the rudiments of an artificial ſyſtem. The attempt, at leaſt, will be laudable, even though we ſhould fail.

Chap. III. Artificial System.

19 Artificial claſſes.

Minerals may be divided into ſix claſſes:

1. Minerals that cannot be fuſed by the blow-pipe *per ſe*.
2. Minerals fuſible *per ſe* by the blow-pipe.
3. Minerals fuſible by the blow-pipe *per ſe* when expoſed to the blue flame, but not when expoſed to the yellow flame.
4. Minerals fuſible *per ſe* by the blow-pipe; and when in fuſion, partly evaporating in a viſible ſmoke.
5. Minerals which totally evaporate before the blow-pipe.
6. Minerals totally ſoluble in muriatic acid with effervеſcence, the ſolution colourleſs.

Under theſe heads we ſhall arrange the ſubjects of the mineral kingdom.

Class I. INFUSIBLE.

ORDER I. Specific gravity from 16 to 12.
Genus I. Colour whitiſh iron grey.
Species 1. Native platinum.

ORDER II. Sp. gr. 8.5844 to 7.006.
Genus I. Attracted by the magnet.
Sp. 1. Native iron.
Genus II. Not attracted by the magnet.
Sp. 1. Native copper.
Flexible and malleable. Colour uſually red.
Sp. 2. Wolfram.
Brittle. Colour uſually brown or black.

ORDER III. Sp. gr. from 6.4509 to 5.8.
Genus I. Forms a blue glaſs with microcoſmic ſalt, which becomes colourleſs in the yellow, but recovers its colour in the blue flame.
Sp. 1. Tungſtat of lime.
Genus II. Forms with microcoſmic ſalt a permanently coloured bead.
Sp. 1. Sulphuret of cobalt.

ORDER IV. Sp. gr. from 4.8 to 4.5.
Genus I. Tinges borax dark green.
Sp. 1. Common magnetic iron ſtone.
Genus II. Tinges borax reddiſh brown.
Sp. 1. Grey ore of manganeſe.

ORDER V. Sp. gr. from 4.4165 to 3.092. Infuſible with fixed alkalies.
Genus I. Hardneſs 20.
Sp. 1. Diamond.
Genus II. Hardneſs 15 to 17. Cauſes ſingle refraction.
Sp. 2. Teleſia.
Sp. 2. Corundum.
Genus III. Hardneſs 13. Single refraction.
Sp. 1. Ruby.
Cryſtallizes in octahedrons.
Genus IV. Hardneſs 12. Single refraction.
Sp. Chryſoberyl.
Genus V. Hardneſs 12. Cauſes double refraction. Becomes electric when heated.
Sp. 1. Topaz.
Genus VI. Hardneſs 10 to 16. Double refraction. Sp. gr. 4.2 to 4.165.
Sp. 1. Zircon.
Genus VII. Hardneſs 6 to 9. Feels greaſy.
Sp. 1. Cyanite.
Genus VIII. Hardneſs 9 to 10. Feel not greaſy. Double refraction. Sp. gr. 3.283 to 3.285.
Sp. 1. Chryſolite.
Genus IX. Hardneſs 12. Infuſible with borax. Colour of large maſſes black, of thin pieces deep green.
Sp. 1. Cylanite.
(*Phoſphat of lime.*)

ORDER VI. Sp. gr. from 2.9829 to 1.987. Infuſible with fixed alkalies.
Genus I. Hardneſs 12.
Sp. 1. Emerald.
Genus II. Hardneſs 10.
Sp. 1. Jade.
Genus III. Hardneſs 6 to 7. Somewhat tranſparent.
Sp. 1. Phoſphat of lime.
Before the blow-pipe becomes ſurrounded with a luminous green vapour.
Genus IV. Hardneſs 6. Opaque.
Sp. 1. Micarelle.
Genus V. Stains the fingers. Colour lead grey.
Sp. 1. Plumbago.
Spaniſh wax rubbed with plumbago does not become electric; or if it does, the electricity is negative. Streak lead grey even on earthen ware.

ORDER VII. Sp. gr. from 4.7385 to 4.569. Fuſible with fixed alkalies.
Genus I. Stains the fingers. Colour lead grey.
Sp. 1. Molybdena.
Spaniſh wax rubbed with molybdena becomes poſitively electric. Streak on earthen ware yellowiſh green.

ORDER VIII. Sp. gr. from 4.1668 to 2.479. Fuſible with fixed alkalies.
* Hardneſs from 10 to 12.

Genus

GENUS I. Ufually white. Cryftals dodecahedrons. Double refraction. Fracture imperfectly conchoidal or fplintery. Brittle.
Sp. 1. Quartz.
GENUS II. Ufually dark brown. Fracture perfectly conchoidal. Brittle. Eafily breaks into fplinters.
Sp. 1. Flint.
GENUS III. Not brittle. Fracture even or imperfectly conchoidal.
Sp. 1. Chalcedony.
Sp. 2. Jafper.
GENUS IV. Forms with potafs a violet glafs, with foda or borax a brown glafs, with microcofmic falt a honey yellow glafs. Colour green. Amorphous.
Sp. 1. Chryfoprafium.
GENUS V. Tinges foda red. The colour difappears before the blue flame, and returns before the yellow flame.
Sp. 1. Oxide of manganefe and barytes.
Sp. 2. Black ore of manganefe.
Sp. 3. Carbonat of manganefe.
(Brown ore of iron. Red ore of iron.)
** Hardnefs 9 to 3.
GENUS VI. Flexible and elaftic in every direction.
Sp. 1. Elaftic quartz.
GENUS VII. Emits white flakes before the blowpipe.
Sp. 1. Blende.
GENUS VIII. Becomes electric when heated.
Sp. 1. Calamine.
GENUS IX. Tinges borax green. Blackens before the blow-pipe.
Sp. 1. Mountain blue.
Colour blue.
Sp. 2. Green carbonat of copper.
Colour green.
GENUS X. Tinges borax green. Becomes attractable by the magnet by the action of the blowpipe.
Sp. 1. Brown iron ore.
Colour brown.
Sp. 2. Red iron ore.
Colour red.
GENUS XI. Tinges borax fmutty yellow. Becomes brownifh black before the blow-pipe.
Sp. 1. Carbonat of iron.
GENUS XII. Feels greafy.
Sp. 1. Steatites.
(Black ore of Manganefe. Carbonat of manganefe. Mica.)

ORDER IX. Sp. gr. from 2.39 to 1.7.
GENUS I. Luftre glaffy.
Sp. 1. Opal.
Sp. 2. Hyalite.
GENUS II. Luftre greafy.
Sp. 1. Pitchftone.
GENUS III. Luftre waxy or pearly.
Sp. 1. Staurolite.

CLASS II. FUSIBLE.

ORDER I. Sp. gr. from 19 to 10.
GENUS I. Colour yellow.
Sp. 1. Native gold.
GENUS II. Colour white.
Sp. 1. Native filver.
GENUS III. Colour yellowifh white.
Sp. 1. Alloy of filver and gold.

ORDER II. Sp. gr. from 7.786 to 4.5.
GENUS I. Flexible and malleable.
Sp. 1. Sulphuret of filver.
** Brittle.
GENUS II. Tinges borax white.
Sp. Tinftone.
GENUS III. Tinges borax green.
Sp. 1. Sulphuret of copper.
Colour bluifh grey.
Sp. 2. Chromat of lead.
Colour aurora red.
Sp. 3. Purple copper ore.
Colour purple.
GENUS IV. Tinges borax faint yellow. Becomes black when expofed to the vapour of fulphuret of ammonia.
Sp. 1. Galena.
Colour bluifh grey. Luftre metallic. Fragments cubic.
Sp. 2. Black lead ore.
Colour black. Luftre metallic.
Sp. 3. Lead ochre.
Colour yellow, grey, or red. Luftre o.
Sp. 4. Carbonat of lead.
Colour white. Luftre waxy.
Sp. 5. Phofphat of lead.
Ufually green. Luftre waxy. After fufion by the blow-pipe cryftallizes on cooling.
Sp. 6. Molybdat of lead.
Colour yellow. Streak white. Luftre waxy.

ORDER III. Sp. gr. from 4.35 to 3.
* Hardnefs 14 to 9.
GENUS I. Melts without frothing into a grey enamel.
Sp. 1. Garnet.
Colour red.
GENUS II. Melts into a brownifh enamel.
Sp. 1. Shorl.
Colour black. Opaque.
GENUS III. Froths and melts into a white enamel.
Sp. 1. Tourmaline.
Becomes electric by heat.
GENUS IV. Froths and melts into a greenifh black enamel.
Sp. 1. Bafaltine.
GENUS V. Froths and melts into a black enamel.
Sp. 1. Thallite.
Colour dark green.
Sp. 2. Thumerftone.
Colour clove brown.
** Hardnefs 5 to 8.
GENUS VI. Melts into a tranfparent glafs.
Sp. 1. Fluat of lime.
Powder phofphorefces when thrown on a hot iron.
GENUS VII. Melts into a black glafs.

Sp. 1.

Artificial Syftem.

Sp. 1. Hornblende.

GENUS VIII. Melts into a black bead with a fulphureous fmell, and depofits a blue oxide on the charcoal.

Sp. 1. Sulphuret of tin.

GENUS IX. Melts into a brown glafs. Tinges borax violet.

Sp. 1 Afbeftoid.

Colour green.

GENUS X. Melts into a brown (?) glafs. When fufed with potafs, and diffolved in water, the folution becomes of a fine orange yellow.

Sp. 1. Chromat of iron.

GENUS XI. Before the blow-pipe yields a bead of copper.

Sp. 1. Red oxide of copper.

(Sulphuret of copper.)

ORDER IV. Sp. gr. from 2.945 to 2.437.

GENUS I. Compofed of fcales.

Sp. 1. Talk.

Feels greafy. Spanifh wax rubbed by it becomes pofitively electric.

GENUS II. Compofed of thin plates, eafily feparable from each other.

Sp. 1. Mica.

Plates flexible and elaftic, may be torn but not broken. Spanifh wax rubbed by it becomes negatively electric.

Sp. 2. Stilbite.

Plates fomewhat flexible. Colour pearl white. Powder renders fyrup of violets green. Froths and melts into an opaque white enamel.

Sp. 3. Lepidolite.

Colour violet. Powder white with a tint of red. Froths and melts into a white femitranfparent enamel full of bubbles.

GENUS III. Texture foliated.

Sp. 1. Felfpar.

Fragments rhomboidal. Hardnefs 9 to 10.

Sp. 2. Leucite.

Always cryftallized. White. Powder renders fyrup of violets green. Hardnefs 8 to 10.

Sp. 3. Argentine felfpar.

Always cryftallized. Two faces dead white, two filvery white.

Sp. 4. Prehnite.

Colour green. Froths and melts into a brown enamel.

GENUS IV. Texture fibrous. Fibres eafily feparated.

Sp. 1. Afbeftus.

Feels fomewhat greafy.

GENUS V. Texture ftriated.

Sp. 1. Ædelite.

Abforbs water. Froths and melts into a frothy mafs.

GENUS VI. Texture earthy or compact.

Sp. 1. Lazulite.

Froths and melts into a yellowifh black mafs. If previoufly calcined, gelatinizes with acids.

Sp. 2. Borat of lime.

Tinges the flame greenifh, froths and melts into a yellowifh enamel garnifhed with fmall projecting points. If the blaft be continued, thefe dart off in fparks.

Artificial Syftem.

ORDER V. Sp. gr. from 2.348 to 0.68.

GENUS I. Hardnefs 10.

Sp. 1. Obfidian.

Colour blackifh, in thin pieces green.

GENUS II. Hardnefs 6 to 8.

Sp. 1. Zeolite.

Gelatinizes with acids. Becomes electric by heat.

GENUS III. Hardnefs 3 to 4.

Sp. 1. Amianthus.

Feels greafy. Texture fibrous.

Sp. 2. Mountain cork.

Elaftic like cork.

CLASS III. FUSIBLE BY THE BLUE FLAME, INFUSIBLE BY THE YELLOW.

GENUS I. Sp. gr. from 4.43 to 4.4.

Sp. 1. Sulphat of barytes

GENUS II. Sp. gr. from 3.96 to 3.51.

Sp. 1. Sulphat of ftrontites.

GENUS III. Sp. gr. from 2.311 to 2.167.

Sp. 1. Sulphat of lime.

CLASS IV. FUSIBLE, AND PARTLY EVAPORATING.

ORDER I. Sp. gr. from 10 to 5.

GENUS I. Colour white or grey. Luftre metallic.

* Sp. gr. 9 to 10.

Sp. 1. Native amalgam.

Tinges gold white. Creaks when cut.

Sp. 2. Alloy of filver and antimony.

Powder greyifh black.

** Sp. gr. from 6.467 to 5.309.

Sp. 3. Sulphuret of bifmuth.

Melts when held to the flame of a candle.

Sp. 4. Dull grey cobalt ore.

Streak bluifh grey. Hardnefs 10. When ftruck emits an arfenical fmell. Luftre fcarcely metallic.

GENUS II. Colour red, at leaft of the ftreak.

Sp. 1. Red filver ore.

Burns with a blue flame.

Sp. 2. Hepatic mercurial ore.

Does not flame, but gives out mercury before the blow-pipe.

GENUS III. Colour blue.

Sp. 1. Blue lead ore.

Burns with a blue flame and fulphureous fmell, and leaves a button of lead.

GENUS IV. Colour yellowifh green.

Sp. 1. Phofphat and arfeniat of lead combined.

When fufed by the blow-pipe, cryftallizes on cooling.

GENUS V. Colour ufually that of copper. Sp. gr.

Artificial System.

gr. 6.6084 to 6 6481.

Sp. 1. Sulphuret of nickel.

Exhales before the blow-pipe an arsenical smoke.

ORDER II. Sp. gr. from 4.6 to 3.44.

Genus I. Colour grey.

Sp. 1. Grey ore of antimony.

Burns with a blue flame, and leaves a white oxyd.

Sp. 2. Grey copper ore.

Crackles before the blow-pipe.

Genus II. Colour yellow.

Sp. 1. Pyrites.

Burns with a blue flame and sulphureous smell, and leaves a brownish bead.

Sp. 2. Yellow copper ore.

Melts into a black mass.

Class V. EVAPORATING.

ORDER I. Sp. gr. 13.6.

Genus I. Fluid.

Sp. 1. Native mercury.

ORDER II. Sp. gr. from 10 to 5.419.

Genus I. Colour red.

Sp. 1. Native cinnibar.

Genus II. Colour white or grey. Lustre metallic.

Sp. 1. Native bismuth.

Melts into a white bead, and then evaporates in a yellowish white smoke. Sp. gr. 9 to 9.5.

Sp. 2. Native antimony.

Melts and evaporates in a grey smoke. Sp. gr. 6.6 to 6.8.

Sp. 3. Native arsenic.

Evaporates without melting, and gives out a garlic smell.

ORDER III. Sp. gr. from 4.8 to 3.33.

Genus I. Colour red.

Sp. 1. Red antimonial ore.

Melts with a sulphureous smell. Sp. gr. 4.7.

Sp. 2. Realgar.

Melts with a garlic smell. Sp. gr. 3.384

Genus II. Colour yellow.

Sp. 1. Orpiment.

Class VI. SOLUBLE with EFFERVESCENCE in MURIATIC ACID.

Natural System.

Genus I. Sp. gr. from 4.338 to 4.3.

Sp. 1. Carbonat of barytes.

Genus II. Sp. gr. from 3.66 to 3.4.

Sp. 1. Carbonat of strontites.

Genus III. Sp. gr. from 2.3 to 1 or under.

Sp. 1. Carbonat of lime.

We have purposely avoided giving names to the classes, orders, and genera; because a more careful examination will doubtless suggest many improvements in the arrangement, and an artificial system ought to be brought to a great degree of perfection before its classes, orders, and genera be finally settled.

We have excluded from this arrangement all those bodies which in the following system are arranged under the class of combustibles; because there can scarcely be any difficulty in distinguishing them both from the other classes and from one another. For similar reasons we have excluded the class of salts.

Chap. IV. Natural System.

Avicenna, a writer of the 11th century, divided minerals into four classes; stones, salts, inflammable bodies, and metals (D). This division has been, in some measure, followed by all succeeding writers. Linnæus, indeed, the first of the moderns who published a system of mineralogy, being guided by the external characters alone, divided minerals into three classes, *petræ*, *mineræ*, *fossilia:* but Avicenna's classes appear among his orders. The same remark may be made with respect to the systems of Wallerius, Wolsterdorf, Cartheuser, and Justi, which appeared in succession after the first publication of Linnæus's *Systema Naturæ*, in 1736. At last in 1758, the system of Cronstedt appeared. He reinstated the classes of Avicenna in their place; and his system was adopted by Bergman, Kirwan, Werner, and the most celebrated mineralogists who have written since. We also shall adopt his classes, with a few slight exceptions; because we are not acquainted with any other division which is intitled to a preference.

10 Natural Classes.

We shall therefore divide this treatise into four classes. I. Stones. II. Salts. III. Combustibles. IV. Ores. The first class comprehends all the minerals which are composed chiefly or entirely of earths; the second, all the combination of acids and alkalies which occur in the mineral kingdom; the third, those minerals which are capable of combustion, and which consist chiefly of sulphur, carbon, and oil; the fourth, the mineral bodies which are composed chiefly of metals.

Class I. EARTHS and STONES.

We shall divide this class into three orders. The first order shall comprehend all chemical combinations of earths with each other; the second order, chemical combinations of earths with acids; and the third order, mechanical mixtures of earths or stones. All the minerals belonging to the first order exhibit the same homogeneous appearance to the eye as if they were simple bodies. We shall therefore, for want of a better name, call the first order *simple*; the second order we shall distinguish by the epithet of *saline*; and the third we shall call

(D) Corpora mineralia in quatuor species dividuntur, scilicet in lapides, et in liquifactiva, sulphurea, et sales. Et horum quædam sunt raræ substantiæ et debilis compositionis, et quædam fortis substantiæ, et quædam ductibilia, et quædam non. *Avicenna de congelatione et conglutinatione lapidum*, Cap. 3. *Theatrum Chemicum* t. iv. p. 997.

Earths and Stones

call *aggregates*; because most of the minerals belonging to it consist of various *simple stones*, cemented, as it were, together.

Order I. SIMPLE STONES.

21 Cronstedt's genera.

Cronstedt divided this order into nine genera, corresponding to nine earths; one of which he thought composed the stones arranged under each genus. The names of his genera, were *calcaræ*, *silicæ*, *granatinæ*, *argillaceæ*, *micacæ*, *fluores*, *asbestinæ*, *zeolithicæ*, *magnesiæ*. All his earths were afterwards found to be compounds, except the first, second, fourth, and ninth. Bergman, therefore, in his Sciagraphia, first published in 1782, reduced the number of genera to five; which was the number of primitive earths known when he wrote. Since that period three new earths have been discovered. Accordingly, in the latest systems of mineralogy, the genera belonging to this order amount to eight. Each genus is named from an earth; and they are arranged in the newest Wernerian system, which we have seen, as follows:

22 Improved

1. Jargon genus.	5. Magnesian genus.
2. Siliceous genus.	6. Calcareous genus.
3. Glucina genus.	7. Barytic genus.
4. Argillaceous genus.	8. Strontian genus.

Mr Kirwan, in his very valuable system of mineralogy, has adopted the same genera. Under each genus, those stones are placed, which are composed chiefly of the earth which gives a name to the genus, or which at least are supposed to possess the characters which distinguish that earth.

23 Still deficient.

A little consideration will be sufficient to discover that there is no natural foundation for these genera. Most stones are composed of two, three, or even four ingredients: and, in many cases, the proportion of two or more of these is nearly equal. Now, under what genus soever such minerals are arranged, the earth which gives it a name must form the smallest part of their composition. Accordingly, it has not been so much the chemical composition, as the external character, which has guided the mineralogist in the distribution of his species. The genera cannot be said properly to have any character at all, nor the species to be connected by any thing else than an arbitrary title. This defect, which must be apparent in the most valuable systems of mineralogy, seems to have arisen chiefly from an attempt to combine together an artificial and natural system. As we have separated these two from each other, it becomes necessary for us to attend more accurately to the natural distribution of genera than has hitherto been done. We have accordingly ventured to form new genera for this order, and we have formed them according to the following rules.

24 New genera.

The only substances which enter into the minerals belonging to this order, in such quantity as to deserve attention, are the following:

Alumina,	Glucina,
Silica,	Zirconia,
Magnesia,	Oxide of iron,
Lime,	Oxide of chromum,
Barytes,	Potass,

Simple Stones.

All those minerals which are composed of the *same* ingredients we arrange under the *same* genus. According to this plan, there must be as many genera as there are varieties of combinations of the above substances existing in nature. The varieties in the *proportion* of the ingredients constitute species. We have not imposed names upon our genera, but, in imitation of Bergman*, have denoted each by a symbol. This symbol is composed of the first letter of every substance which enters in any considerable quantity into the composition of the minerals arranged under the genus denoted by it. Thus, suppose the minerals of a genus to be composed of *alumina*, *silica*, and *oxide of iron*, we denote the genus by the symbol *asi*. The letters are arranged according to the proportion of the ingredients; that which enters in the greatest proportion being put first, and the others in their order. Thus the genus *asi* is composed of a considerable proportion of alumina, of a smaller proportion of silica, and contains least of all of iron. By this contrivance, the symbol of a genus contains, within the compass of a few letters, a pretty accurate description of its nature and character. Where the proportions of the ingredients vary in the same genus so much, that the letters which constitute its symbol change their place, we subdivide the genus into parts; and whenever the minerals belonging to any genus become too numerous, advantage may be taken of these subdivisions, and each of them may be formed into a separate genus. At present this seems unnecessary (E).

* *Opusc* iv. 231.

The following is a view of the different genera belonging to this order, denoted each by its symbol. Every genus is followed by the species included under it; and the whole are in the order which we mean to follow in describing them:

I. A.
Telesia,
Corundum,
Native alumina.

II. AMC.
Ruby.

III. AIM.
Ceylanite.

IV. S.
Quartz,
Elastic quartz,
Flint,
Opal,
Pitchstone,
Chrysoprasium.

V. 1. AS.
Topaz,
Sommite,
Shorlite.

2. SA.
Rubellite,
Hornslate,
Hornstone,
Chalcedony,
Jasper.
Tripoli.

VI. 1. ASI.
Micarell,
Shorl,
Granatite,

2. SAI.
Tourmaline,
Argentine felspar,
Mica,
Talc,
Basaltine,
Hornblende,
Obsidian,
Petrilite,
Felsite.

VII. SAP.
Felspar,
Lepidolite,
Leucite.

VIII. SAG.
Emerald.

IX. SAB.
Staurolite.

X. 1. ASL.
Chrysoberyl.

2. SAL.
Hyalite,
Ædelite.

3. SAWL

(E) We need hardly remark, that the last three genera of Werner belong to the second order of the first class of this treatise.

Earths and Stones.

3. SAWL.
Zeolite,
Stilbite,
Analcime.
4. SLA.
Lazulite.
XI. SALI.
Garnet,
Thumerstone,
Prehnite,
Thallite.
XII. 1. AMS.
Cyanite.
2. MSA.
Serpentine.
XIII. MSAI.
Potstone,
Chlorite.
XIV. SLAM.
Siliceous spar.
XV. SAMLI.
Argillite.
XVI. SM.
Kiffekill,
Steatites.
XVII. MSI.
Chrysolite,
Jade.
XVIII. SML.
Asbestus,
Asbestinite.
XIX. 1. SILM.
Pyroxen,
Asbestoid.
2. SMIL.
Actinolite.
XX. SL.
Shistose hornstone.
XXI. ZS.
Zircon.

25
I. A.
Telesia.

Genus I. A.

Species 1. Telesia (F).

Oriental ruby, *sapphire*, and *topaz* of mineralogists.—*Rubis d'orient* of De Lisle.

Three stones, distinguished from each other by their colour, have long been held in high estimation on account of their hardness and beauty. These stones were known among lapidaries by the names of *ruby*, *sapphire*, and *topaz*, and the epithet *oriental* was usually added, to distinguish them from other three, known by the same names and the same colours, but very inferior in hardness and beauty. Mineralogists were accustomed to consider these stones as three distinct species, till Romé de Lisle observed that they agreed in the form of their crystals, their hardness, and most of their other properties. These observations were sufficient to constitute them one species; and accordingly they were made one species by Romé de Lisle himself, by Kirwan, and several other modern mineralogical writers. But this species was destitute of a proper name, till Mr Hauy, whose labours, distinguished equally by their ingenuity and accuracy, have contributed not a little to the progress of mineralogy, denominated it *telesia*, from the Greek word τιλεσιος, which signifies *perfect*.

The telesia is found in the East Indies, especially in Pegu and the island of Ceylon; and it is most commonly crystallized. The crystals are of no great size: Their *primitive* form, according to Mr Hauy, is a regular six-sided prism, divisible in directions parallel both to its bases and its sides; and consequently giving for the form of its primitive nucleus, or of its *integrant molecule*, an equilateral three-sided prism *. The most usual variety is a dodecahedron, in which the telesia appears under the form of two very long slender six-sided pyramids, joined base to base †. The sides of these pyramids are isosceles triangles, having the angle at their vertex $22° 54'$, and each of those at the base $78° 48'$ (G). The inclination of a side of one pyramid to a contiguous side of the other pyramid is $139° 54$ ‡. In some specimens the summits of the pyramids are wanting, so that the crystal has the appearance of a six sided prism, somewhat thicker in the middle than towards the extremities §. The three alternate angles at each extremity of this prism are also sometimes wanting, and a small triangular face instead of them, which renders the bases of the supposed prism nine-sided. The inclination of each of these small triangles to the base is $122° 18$ ¶. For figures of these crystals we refer the reader to Romé de Lisle and Hauy ‖.

* *Ann de Chim.* xvii. 3. Plate XXVI. f. 1.

‡ *Ibid* and *Romé de Lisle*, ii. 315.

§ Fig. 2.

¶ *Hauy, ibid.*

‖ *Ibid.*

The texture of the telesia is foliated, and the joints are parallel to the base of the prism *. Its lustre varies from 3 to 4 (H). Transparency usually 3 or 4, sometimes only 2. It causes only a single refraction. Specific gravity from 4. to 4.288. Hardness from 15 to 17. It is either colourless or red, yellow or blue. These colours have induced lapidaries to divide the telesia into the three following varieties.

* *Hauy.*

Variety 1. Red telesia.

Oriental ruby.

Colour carmine red, sometimes verging towards violet. Sometimes various colours appear in the same stone, as red and white, red and blue, orange red. Hardness 17. Sp. gr. 4.288.

Variety 2. Yellow telesia.

Oriental topaz.

Colour golden yellow. Transp. 4. Hardness 15. Sp. gr. 4.0106.

Variety 3. Blue telesia.

Oriental sapphyr.

Colour Berlin blue, often so very faint that the stone appears almost colourless. Transp. 3, 4, 2. Hardness 17. Sp. gr. 3.991 to 4.083 †. That variety is not probably the same with the sapphyr of the ancients. Their sapphyr was distinguished by gold-coloured spots, none of which are to be seen in the sapphyr of the moderns ‡.

† *Greville, Nicholson's Jour.* iii. 11.

‡ *Hill's Theophrastus*, περι των λιθων, p. 100.

A specimen of this last variety, analysed by Mr Klaproth, was found to contain in 100 parts,

98.5	alumina,
1.0	oxyd of iron,
0.5	lime,
100.0 §	

§ *Beiträge*, i. 81.

The colouring matter of all these varieties is, according to Bergman's experiments, iron in different states of oxydation. He found that the topaz contained .06, the ruby .1, and the sapphyr .02 of that metal ‖. But when these experiments were made, the analysis of stones was not arrived at a sufficient degree of perfection to ensure accuracy. No conclusion, therefore, can be drawn from these experiments, even though we were certain that they were made upon the real varieties of telesia.

‖ *Bergman*, ii. 96.

SPECIES

(F) See *Kirwan's Mineralogy*, I. 250.—*Gmelin's Systema Naturæ of Linnæus*, III. 170.—*Romé de Lisle's Crystallographie*, II. 212.—*Bermanni Opuscula*, II. 72.

(G) In some instances, the angle at the vertex is $31°$, those at the base $74° 30'$, and the inclination of two triangles $122° 36'$. See *Hauy, ibid.*

(H) When the *kind* of lustre is not specified, as in the present instance, the *common* is always meant.

Earths and Stones. Simple Stones.

26 Corundum.

SPECIES 2. Corundum (1).

Corundum of Gmelin—*Admantine fpar* of Klaproth and Kirwan—*Corindon* of Hauy—*Corivindum* of Woodward.

This ftone, though it appears to have been known to Mr Woodward, may be faid to have been firft diftinguifhed from other minerals by Dr Black. In 1768, Mr Berry, a lapidary in Edinburgh, received a box of it from Dr Anderfon of Madras. Dr Black afcertained, that thefe fpecimens differed from all the ftones known to Europeans; and, in confequence of its hardnefs, it obtained the name of *adamantine fpar*. Notwithftanding this, it could fcarcely be faid to have been known to European mineralogifts till Mr Greville of London, who has doné fo much to promote the fcience of mineralogy, obtained fpecimens of it, in 1784, from India, and diftributed them among the moft eminent chemifts, in order to be analyfed. Mr Greville alfo learned, that its Indian name was Corundum. It is found in Indoftan, not far from the river Cavery, which is fouth from Madras, in a rocky matrix, of confiderable hardnefs, partaking of the nature of the ftone itfelf *. It occurs alfo in China; and a fubftance, not unlike the matrix of corundum, has been found in Teree, one of the weftern iflands in Scotland †.

The corundum is ufually cryftallized. Its primitive form, difcovered by Mr Hauy ‡ and the Count de Bournon §, is a rhomboidal parallelopiped, whofe fides are equal rhombs, with angles of 86° and 94°, according to Bournon, or whofe diagonals are to each other as $\sqrt{17}$ to $\sqrt{15}$, according to Hauy; which is very nearly the fame thing ¶. The moft common variety, for the primitive form has never yet been found, is the regular fix-fided prifm, the alternate angles of which are fometimes wanting ‖, and the triangular faces, which occupy their place, are inclined to the bafe at an angle of 122° 34′ *. Sometimes the corundum is cryftallized in the form of a fix-fided pyramid, the apex of which is generally wanting. For a defcription and figure of thefe, and all the other varieties of corundum hitherto obferved, we refer the reader to the differtation of the Count de Bournon on the fubject †.

* Garrow and Greville, Nicholfon's Jour. ii. 540.
† Greville, ibid.
‡ Jour. de Min. N° xxviii. 262.
§ Nicholfon's Jour. ii. 541.
¶ Fig. 3.
‖ Fig. 4.
* De Bournon.
† See alfo Hauy, Jour. de min. N° xxviii. 262.

The texture of the corundum is foliated, and the natural joints are parallel to the faces of the primitive rhomboidal parallelopiped. Luftre, when in the direction of the laminæ, 3; when broken acrofs, 0. Opake, except when in very thin pieces. Hardnefs 15. Sp. gr. from 37.10 to 4.180 ‡. Colour grey, often with various fhades of blue and green.

According to the analyfis of Klaproth, the corundum of India is compofed of

89.5	alumina,
5.5	filica,
1.25	oxide of iron,
96.25 §.	

‡ Klaproth. See alfo Mr Greville, Nicholfon's Jour. iii. 11.
§ Beiträge, i. 77.

A fpecimen from China of

84.0	alumina,
6.5	filica,
7.5	oxide of iron,
98.0 ‖.	

‖ Ibid. i. 73.

Notwithftanding the quantity of filica and of iron which thefe analyfes exhibit in the corundum, we have been induced to include it in the prefent genus on account of the ftrong refemblance between it and the third variety of telefia. The ftriking refemblance between the cryftals of telefia and corundum will appear evident, even from the fuperficial defcription which we have given; and the obfervations of De Bournon ¶ render this refemblance ftill more ftriking. It is not improbable, therefore, as Mr Greville and the Count de Bournon have fuggefted, that corundum may be only a variety of telefia, and that the feeming difference in their ingredients is owing to the impurity of thofe fpecimens of corundum which have hitherto been brought to Europe. Let not the difference which has been found in the primitive form of thefe ftones be confidered as an infuperable objection, till the fubject has been again examined with this precife object in view; for nothing is eafier than to commit an overfight in fuch difficult examinations.

¶ Nicholfon's Jour. iii. 9.

27 Native alumina.

SPECIES 3. Native alumina (K).

This fubftance has been found at Halles in Saxony in compact kidney-form maffes. Its confiftence is earthy. Luftre 0. Opaque. Hardnefs 4. Brittle. Sp. gr. moderate. Feels foft, but meagre. Adheres very flightly to the tongue. Stains very flightly. Colour pure white. Does not readily diffufe itfelf in water.

It confifts of pure alumina, mixed with a fmall quantity of carbonat of lime, and fometimes of fulphat of lime *.

* Schreber.

28 G. II. AMC. Ruby.

GENUS II. AMC.

SPECIES 1. Ruby (L).

Spinel and *balafs Ruby* of Kirwan—*Ruby* of Hauy—*Rubis fpinelle octoedre* of De Lifle—*Spinellus* of Gmelin.

This ftone, which comes from the ifland of Ceylon, is ufually cryftallized. The primitive form of its cryftals is a regular octohedron, compofed of two four-fided pyramids applied bafe to bafe, each of the fides of which is an equilateral triangle † (M). In fome cafes two oppofite fides of the pyramids are broader than the other two; and fometimes the edges of the octohedron are wanting, and narrow faces in their place. For figures and defcriptions of thefe, and other varieties of thefe cryftals, we refer the reader to *Romé de Lifle* and the *Abbé Eftner* ‡.

The texture of the ruby is foliated. Its luftre is 3. Tranfp. 3.4. It caufes a fingle refraction. Hardnefs 13. Sp. gr. 3.570 § to 3.625 ¶. Colour red; if deep, the ruby is ufually called *balafs*; if pale rofy, *fpinell*. The

† Fig. 5.
‡ Cryftal. ii. 226. Eftner's Miner. 73.
§ Klaproth.
¶ Hatchett and Greville.

(I) See *Kirwan's Mineralogy*, I.—*Klaproth in Beob. der Berlin*, VIII. 295. and *Beiträge*, I. 47.—*Mr Greville* and the *Count de Bournon* in the *Philofophical Tranfactions* 1798, p. 403. and in *Nicholfon's Journal*, II. 540. and III. 5.—*Mr Hauy Jour. de Phyf.* XXX. 193. and *Jour. de Min.* N° XXVIII. 262.

(K) See *Kirwan's Mineralogy*, I. 175, and *Schreber*. 15. *Stück*, p. 209.

(L) See *Kirwan's Min.* I. 253.—*Romé de Lifle*, II. 224.—*Klaproth Beob. der Berlin*, III. 336. and *Beiträge*, II. 1.—*Vauquelin Ann. de Chim.* XXVII. 3. and XXXI. 141.

(M) We fhall afterwards diftinguifh this octohedron either by the epithet *regular* or *aluminiform*, becaufe it is the well-known form of cryftals of alum.

Earths and Stones. The ruby, according to the analyſis of Vauquelin, is compoſed of

86.00	alumina,
8.50	magneſia,
5.25	chromic acid.
99.75 *	

* Ann. de Chim. xxvii. 15.

The ancients ſeem to have claſſed this ſtone among their hyacinths †.

† Plinii, l. 37. c. 9.

29

Genus III. aim.

G. III. aim. Ceylanite.

species 1. Ceylanite.

The mineral denominated *ceylanite*, from the iſland of Ceylon, from which it was brought into Europe, had been obſerved by Romé de Liſle ‡; but was firſt deſcribed by La Metherie in the Journal de Phyſique for January 1793.

‡ Cryſtallog. iii. 180. Note 21.

It is moſt commonly found in rounded maſſes; but ſometimes alſo cryſtallized. The primitive form of its cryſtals is a regular octahedron: it commonly occurs under this form, but more commonly the edges of the octahedron are wanting, and ſmall faces in their place §.

§ Hauy, Jour. de Min. N° xxxviii. 264.

The fracture of the ceylanite is conchoidal ‖. Its internal luſtre is glaſſy. Nearly opaque, except when in very thin pieces. Hardneſs 12. Sp. gr. from 3.7647 * to 3.793 †. Colour of the maſs, black; of very thin pieces, deep green. Powder, greeniſh grey. According to the analyſis of Deſcotils, the ceylanite is compoſed of

‖ Ibid. 263. * Hauy. † Deſcotils.

68	alumina,
16	oxide of iron,
12	magneſia,
2	ſilica.
98 ‡	

‡ Ann. de Chim. xxiii. 113.

30

Genus IV. s.

G. IV. s. Quartz.

species 1. Quartz §.

§ Kirwan's Min. i. 241.

This ſtone, which is very common in moſt mountainous countries, is ſometimes cryſtallized, and ſometimes amorphous. The primitive form of its cryſtals, according to Mr Hauy, is a rhomboidal parallelopiped; the angles of whoſe rhombs are 93° 22′, and 86° 38′; ſo that it does not differ much from a cube ‖. The moſt common variety is a dodecahedron *, compoſed of two ſix-ſided pyramids, applied baſe to baſe, whoſe ſides are iſoſceles triangles, having the angle at the vertex 40°, and each of the angles at the baſe 70°; the inclination of a ſide of one pyramid to the contiguous ſide of the other pyramid is 104°. There is often a ſix-ſided priſm interpoſed between the two pyramids, the ſides of which always correſpond with thoſe of the pyramids †. For a deſcription and figure of the other varieties of quartz cryſtals, and for a demonſtration of the law which they have followed in cryſtallizing, we refer the reader to *Romé de Liſle* ‡ and *Mr Hauy* §.

‖ Jour. de Min. N° xxviii. 255. * Fig. 6. † Fig. 7. ‡ Cryſtal. ii. 71. § Mem. Par. 1786, p. 78. See alſo Lametherie, Jour. de Phyſ. xlii. 470.

The texture of quartz is more or leſs foliated. Fracture, conchoidal or ſplintery. Its luſtre varies from 3 to 1, and its tranſparency from 4 to 1; and in ſome caſes it is opaque. It cauſes a double refraction. Hardneſs, from 10 to 11. Sp. gr. from 2.64 to 2.67, and in one variety 2.691. Its colour is exceedingly various; a circumſtance which has induced mineralogiſts to divide it into numerous varieties. Of theſe the following are the chief:

Simple Stones.

1. Pure colourleſs, perfectly tranſparent cryſtallized quartz, having much the appearance of artificial cryſtal: known by the name of *rock cryſtal*.

2. Quartz leſs tranſparent, and with a ſplintery fracture, has uſually been diſtinguiſhed by the name of *quartz*, and ſeparated from rock cryſtal. As there is no occaſion for this ſeparation, we have, in imitation of Mr Hauy, choſen the word quartz for the *ſpecific name*, comprehending under it all the varieties.

3. Blood red quartz; formerly called *compoſtella hyacinth*, and by Hauy *quartz hematoide*. It owes its colour to oxide of iron. The mineral known to mineralogiſts by the name of *ſinople*, and conſidered by them as a variety of *jaſper*, has been diſcovered by Dolomieu to be merely this variety of quartz in an amorphous ſtate *.

* Jour. de Min. N° xxviii. 255.

4. Yellow quartz; called falſe topaz.

5. Roſy red quartz; called Bohemian ruby.

For a fuller enumeration of theſe varieties, we refer the reader to *Smeiſſer's Mineralogy* †, *Kirwan's Mineralogy* ‡, and Gmelin's edition of the *Syſtema Naturæ* of Linnæus §. This laſt writer, however, has arranged ſeveral minerals under quartz which do not belong to it.

† i. 89. ‡ i. 244. § iii. 194.

Pure quartz is compoſed entirely of ſilica; but ſome of the varieties of this ſpecies are contaminated with metallic oxides, and with a ſmall quantity of other earths.

31 Elaſtic quartz.

species 2. Elaſtic Quartz (n).

This ſingular ſtone is moderately elaſtic, and flexible in every direction. Texture, earthy. Luſtre 0 or 1. Hardneſs, 9. Brittle. Sp. gr. 2.624. Colour, greyiſh white. Phoſphoreſces when ſcraped with a knife in the dark. The ſpecimen analyſed by Mr Klaproth contained

96.5	ſilica,
2.5	alumina,
5	oxide of iron.
99.5 ‖	

‖ Beiträge, ii. 116.

32 Flint.

species 3. Flint (o).

Pyromachus—Pierre a fuſil—Silex of Hauy.

This ſtone, which has become ſo neceſſary in modern war, is found in pieces of different ſizes, and uſually of a figure more or leſs globular, commonly among chalk, and often arranged in ſome kind of order. In Saxony it is ſaid to have been found cryſtallized in hexahedrons, compoſed of two low three-ſided pyramids applied baſe to baſe *.

* Gmelin's Syſtema Naturæ, iii. 318.

Its texture is compact. Its fracture, ſmooth conchoidal. Luſtre, external, 0, the ſtones being always covered by a white cruſt; internal, 1, inclining to greaſy. Tranſp. 2; when very thin, 3. Hardneſs, 10 or 11. Sp. gr. from 2.58 to 2.63. Colour varies from honey yellow to browniſh black. Very brittle, and ſplits into ſplinters in every direction. Two pieces of flint rubbed ſmartly together phoſphoreſce, and emit a peculiar odour. When heated it decrepitates, and becomes white and opaque. When expoſed long to the air

(n) *Kirwan's Min.* I. 316.—*Gerhard, Mem. Berlin,* 1783, 107.—*Klaproth's Beiträge,* 2 *Band.* 113. See alſo *Jour. de Phyſ.* XLI. 91.

(o) *Kirwan's Min.* I. 301.—*Dolomieu, Jour. de Min.* N° XXXIII. 693. and *Salivet, ibid.* 713. Theſe laſt gentlemen give the only accurate account of the method of making gun flints.

Earths and Stones.

air it often becomes covered with a white cruft. A fpecimen of flint, analyfed by Klaproth, contained

98.00 filica,
.50 lime,
.25 alumina,
0.25 oxide of iron,
1.00 water.

100.00 *

* Beiträge, i. 46.

Another fpecimen, analyfed by Dolomieu, was compofed of 97 filica,
1 alumina and oxide of iron,
2 water.

100 †

† Jour. de Min. N° xxxiii. 702.

The white cruft with which flint is enveloped, confifts of the fame ingredients, and alfo a little carbonat of lime. Dolomieu difcovered that water is effential to flint; for when it is feparated by heat the ftone lofes its properties ‡.

‡ Ibid.

The manufacture of gun flints is chiefly confined to two or three departments in France. The operation is exceedingly fimple: a good workman will make 1000 flints in a day. The whole art confifts in ftriking the ftone repeatedly with a kind of mallet, and bringing off at each ftroke a fplinter, fharp at one end and thicker at the other. Thefe fplinters are afterwards fhaped at pleafure, by laying the line at which it is wifhed they fhould break, upon a fharp iron inftrument, and then giving it repeatedly fmall blows with a mallet. During the whole operation the workman holds the ftone in his hand, or merely fupports it on his knee §.

§ Ibid.

33 Opal.

SPECIES 4. Opal (P).

This ftone is found in many parts of Europe. It is ufually amorphous. Its fracture is conchoidal, commonly fomewhat tranfparent. Hardnefs from 6 to 10. Sp. gr. from 1.7 to 2.66. The lownefs of its fpecific gravity, in fome cafes, is to be afcribed to accidental cavities which the ftone contains. Thefe are fometimes filled with drops of water. Some fpecimens of opal have the property of emitting various coloured rays, with a particular effulgency, when placed between the eye and the light. The opals which poffefs this property, are diftinguifhed by lapidaries by the epithet *oriental;* and often by mineralogifts by the epithet *nobilis.* This property rendered the ftone much efteemed by the ancients.

Variety 1. Opal edler—*Opalus nobilis.*

Luftre glaffy, 3. Tranfp. 3 to 2. Hardnefs, 6 to 8. Colour, ufually light bluifh white, fometimes yellow or green. When heated it becomes opaque, and fometimes is decompofed by the action of the atmofphere. Hence it feems to follow, that water enters effentially into its compofition. A fpecimen of this variety, analyfed by Klaproth, contained

90 filica,
10 water.

100 *

* Beiträge, ii. 153.

Variety 2. Semi-opal.

Fracture, imperfectly conchoidal. Luftre, glaffy, 2. Tranfp. 2 to 3. Hardnefs, 7 to 9. Its colours are very various, greys, yellows, reds, browns, greens of different kinds.

Simple Stones.

Specimens of this variety fometimes occur with rifts: thefe readily imbibe water, and therefore adhere to the tongue. Thefe fpecimens fometimes become tranfparent when foaked in water, by imbibing that fluid. They are then called *hydrophanes.*

Variety 3. Cat's eye *.

* Kirwan's Min. i. 301. Klaproth, Beiträge, i. 90.

This variety comes from Ceylon, and is feldom feen by European mineralogifts till it has been polifhed by the lapidary. Mr Klaproth has defcribed a fpecimen which he received in its natural ftate from Mr Greville of London. Its figure was nearly fquare, with fharp edges, a rough furface, and a good deal of brilliancy.

Its texture is imperfectly foliated. Luftre greafy, 2. Tranfp. 3 to 2. Hardnefs 10. Sp. gr. 2.56 to 2.66. Colour, grey; with a tinge of green, yellow, or white: or brown, with a tinge of yellow or red. In certain pofitions it reflects a fplendid white, as does the eye of a cat; hence the name of this ftone.

Two fpecimens, analyfed by Klaproth, the firft from Ceylon, the other from Malabar, were compofed of

95.00	94.50	filica,
1.75	2.00	alumina,
1.50	1.50	lime,
0.25	0.25	oxide of iron.
98.5†	98 25‡	

† Beiträge, i. 94. ‡ Ibid. p. 96.

34 Pitchftone.

SPECIES 5. Pitchftone §.
Menelites.

This ftone, which occurs in different parts of Germany, France, and other countries, has obtained its name from fome refemblance which it has been fuppofed to have to pitch. It is moft ufually in amorphous pieces of different fizes; and it has been found alfo cryftallized in fix-fided prifms, terminated by three-fided pyramids.

§ Kir. Min. i. 292.—Daubanton, Mem. Par. 1787, p. 86.

Its texture is conchoidal and uneven, and fometimes approaches the fplintery. Luftre greafy, from 3 to 1. Tranfp. 2 to 1, fometimes 0. Hardnefs 8 to 10. Exceedingly brittle; it yields even to the nail of the finger. Sp. gr. 2.049 to 2.39. Its colours are numerous, greyifh black, bluifh grey, green, red, yellow of different fhades. Sometimes feveral of thefe colours appear together in the fame ftone. A fpecimen of pitchftone from Mefnil-montant near Paris ‖, analyfed by Mr Klaproth, contained

‖ See Jour. de Phyf. xxxi. 219.

85.5 filiea,
11.0 air and water,
1.0 alumina,
.5 iron,
.5 lime and magnefia.

98.5 ¶

¶ Beiträge, ii. 169.

35 Chryfoprafium.

SPECIES 6. Chryfoprafium (Q).

This mineral, which is found in different parts of Germany, particularly near Kofemütz in Silefia, is always amorphous. Its fracture is either even or inclining to the fplintery. Scarcely any luftre. Tranfp. 2 to 3. Hardnefs 10 to 12. Sp. gr. 2.479. Colour, green. In a heat of 130° Wedgewood it whitens and becomes opaque.

A

(P) *Kirwan's Min.* I. 289.—*Hauy, Jour. d'Hift. Nat.* II. 9.—*Delius, Nouv. Jour. de Phyf.* I. 45.
(Q) *Kirwan's Min.* I.—*Lehmann, Mem. Berlin,* 1755, p. 202.—*Klaproth Beitrage,* II. 127.

Earths and Stones.

A ſpecimen of this ſtone, analyſed by Mr Klaproth, contained 96.16 ſilica,
1.00 oxide of nickel,
0.83 lime,
0.08 alumina,
0.08 oxide of iron.
98.15 ‡

‡ Beitrage, ii. 133.

36

G. V. I. AS. Topaz.

GENUS V. 1. AS.

SPECIES 1. Topaz (R).

Occidental ruby, topaz, and *ſapphyr.*

The name *topaz* has been reſtricted by Mr Hauy to the ſtones called by mineralogiſts occidental ruby, topaz, and ſapphyr; which, agreeing in their cryſtallization and moſt of their properties, were arranged under one ſpecies by Mr Romé de Liſle. The word *topaz*, derived from an iſland in the Red Sea (S), where the ancients uſed to find topazes, was applied by them to a mineral very different from ours. One variety of our topaz they denominated *chryſolite.*

The topaz is found in Saxony, Bohemia, Siberia, and Brazil, mixed with other minerals in granite rocks.

It is commonly cryſtallized. The primitive form of its cryſtals is a priſm whoſe ſides are rectangles, and baſes rhombs, having their greateſt angles 124° 22′, and the integral molecule has the ſame form †; and the height of the priſm is to a ſide of the rhomboidal baſes as 3 to 2 ‡. The different varieties of topaz cryſtals hitherto obſerved, amount to 6. Five of theſe are eight-ſided priſms, terminated by four-ſided pyramids, or wedge ſhaped ſummits, or by irregular figures of 7, 13, or 15 ſides §; the laſt variety is a twelve-ſided priſm, terminated by ſix-ſided pyramids wanting the apex. For an accurate deſcription and figure of theſe varieties we refer the reader to Mr Hauy ‖.

† Hauy, Jour. de Min. N° xxviii 287.
‡ Fig. 8.
§ Fig. 9.

The texture of the topaz is foliated. Its luſtre is from 2 to 4. Tranſp. from 2 to 4. It cauſes a double refraction. Hardneſs 12 to 14. Sp. gr. from 3.5311 to 3.564. The Siberian and Brazil topazes, when heated, become poſitively electrified on one ſide, and negatively on the other ¶. It is infuſible by the blow-pipe. The yellow topaz of Brazil becomes red when expoſed to a ſtrong heat in a crucible; that of Saxony becomes white by the ſame proceſs. This ſhews us that the colouring matter of theſe two ſtones is different.

‖ Jour. de Min. ibid.
¶ Hauy, ibid.

The colour of the topaz is various, which has induced mineralogiſts to divide it into the following varieties:

1. Red topaz, of a red colour inclining to yellow; called *Brazilian* or *occidental ruby.*

2. Yellow topaz, of a golden yellow colour, and ſometimes alſo nearly white; called *occidental* or *Brazil topaz.* The powder of this and the following variety cauſes ſyrup of violets to aſſume a green colour *.

3. *Saxon topaz.* It is of a pale wine yellow colour, and ſometimes greyiſh white.

* Vauquelin, Jour. de Min. N° xxix. 165.

Simple Stones.

4. *Aigue marine.* It is of a bluiſh or pale green colour.

5. *Occidental ſapphyr.* It is of a blue colour; and ſometimes white.

A ſpecimen of white Saxon topaz, analyſed by Vauquelin, contained 68 alumina,
31 ſilica.
99 *.

* Jour. de Min. N° xxiv. 3.

37

SPECIES 2. Sommite.

This ſtone was called ſommite by La Metherie, from the mountain Somma, where it was firſt found. It is Sommite.
uſually mixed with volcanic productions. It cryſtallizes in ſix-ſided priſms, ſometimes terminated by pyramids. Colour white. Somewhat tranſparent. Sp. gr. 3.2741. Infuſible by the blow-pipe. According to the analyſis of Vauquelin, it is compoſed of
49 alumina,
46 ſilica,
2 lime,
1 oxide of iron.
98 †

† Ibid. N° xxviii. 279.

38

SPECIES 3. Shorlite ‡.

This ſtone, which received its name from Mr Klaproth, is generally found, in irregular oblong maſſes or columns, inſerted in granite. Its texture is foliated. Fracture uneven. Luſtre 2. Tranſparency 2 to 1. Hardneſs 9 to 10. Sp. gr. 3.53. Colour greeniſh white, or ſulphur yellow. Not altered by heat. According to the analyſis of Klaproth, it is compoſed of
50 alumina,
50 ſilica.
100

‡ Kirwan's Min. i. 286.

39

G. V. 2. SA. Rubellite.

GENUS V. 2. SA.

SPECIES 4. Rubellite (T).

Red ſhorl of Siberia.

This ſtone is found in Siberia mixed with white quartz. It is cryſtallized in ſmall needles, which are grouped together and traverſe the quartz in various directions. Texture fibrous. Fracture even, inclining to the conchoidal. Tranſparency 2; at the edges 3. Hardneſs 10. Brittle. Sp. gr. 3.1. Colour crimſon, blood or peach red. By expoſure to a red heat it becomes ſnow white; but loſes none of its weight. It tinges ſoda blue, but does not melt with it.

According to the analyſis of Mr Bindheim, it is compoſed of 57 ſilica,
35 alumina,
5 oxides of iron and manganeſe.
97

40

Hornſlate.

SPECIES 5. Hornſlate (U).

Shiſtoſe porphyry.

This ſtone, which occurs in mountains, is generally amorphous; but ſometimes alſo in columns. Structure

(R) *Kirwan's Min.* I. 254.—*Pott. Mem. Berlin,* 1747, p. 46.—*Margraf, ibid.* 1776, p. 73. *and* 160.—*Henkel. Act. Acad. Nat. Cur.* IV. 316.

(S) It got its name from τοπαζα, *to ſeek;* becauſe the iſland was often ſurrounded with fog, and therefore difficult to find. See *Plinii lb.* 37. c. 8.

(T) *Kirwan's Min.* I. 288. *Bindheim, Crell's Annals,* 1792, p. 320.

(U) *Kirwan's Min.* I. 307.—*Wiegleb, Crell's Annals,* 1787. 1 *Band.* 302.—See alſo *Reuſs. Semml. Natur. Hiſt. Aufsäze,* p. 207.

Earths and Stones.

ture flaty. Texture foliated. Fracture uneven and fplintery; fometimes approaching the conchoidal. Luftre 0. Transparency 1 or 0. Hardnefs about 10. Sp. gr. from 2.512 to 2.7. Colour different fhades of *grey*, from *afh* to *bluifh* or *olive green*. Melts at 145° Wedgewood into an enamel. A fpecimen, analyfed by Wedgewood, contained

73.0	filica,
23.9	alumina,
3.5	iron.
100.4	

41 Hornftone.

SPECIES 6. Hornftone (x).

Petrofilex—Chert.

This ftone, which makes a part of many mountains, is ufually amorphous; but, as Mr Kirwan informs us, it has been found cryftallized by Mr Beyer on Schneeberg. Its cryftals are fix-fided prifms, fometimes terminated by pyramids: hexahedrons, confifting of two three-fided pyramids applied bafe to bafe; and cubes, or fix-fided plates *. Its texture is foliated. Fracture fplintery, and fometimes conchoidal. Luftre 0. Tranfparency 1 to 2. The cryftals are fometimes opaque. Hardnefs 7 to 9. Sp. gr. 2.532 to 2.653. Colour ufually dark blue: but hornftone occurs alfo of the following colours; grey, red, blue, green, and brown of different fhades †,

* *Kirwan*, i. 303.

† *Schmeiffer's Min.* i. 103.

According to Kirwan, it is compofed of

72	filica,
22	alumina,
6	carbonat of lime.
100 ‡	

‡ *Ibid.* p. 305.

42 Chalcedony.

SPECIES 7. Chalcedony.

This ftone is found abundantly in many countries, particularly in Iceland and the Faro iflands. It is moft commonly amorphous, ftalactitical, or in rounded maffes; but it occurs alfo cryftallized in fix-fided prifms, terminated by pyramids, or more commonly in four or fix fided pyramids, whofe fides are convex. Surface rough. Fracture more or lefs conchoidal. Luftre 1. Somewhat tranfparent. Hardnefs 10 to 11. Sp. gr. 2.56 to 2.665. Not brittle.

According to Bergman, the chalcedony of Foroe is compofed of

84	filica,
16	alumina, mixed with iron.
100	

Variety 1. Common chalcedony.

Fracture even, inclining to conchoidal. Tranfparency 2 to 3; fometimes 1. Its colours are various; it is moft commonly greyifh, with a tint of yellow, green, blue, or pearl; often alfo white, green, red, yellow, brown, black, or dotted with red. When ftriped white and black, or brown, alternately, it is called *onyx*; when ftriped white and grey, it is called *chalcedonix*. Black or brown chalcedony, when held between the eye and a ftrong light, appears dark red.

Variety 2. Cornelian.

Fracture conchoidal. Tranfparency 3 to 1; often cloudy. Its colours are various fhapes of red, brown, and yellow. Several colours often appear in the fame mafs. To this variety belong many of the ftones known by the name of *Scotch pebbles*.

Simple Stones.

43 Jafper.

SPECIES 8. Jafper (y).

This ftone is an ingredient in the compofition of many mountains. It occurs ufually in large amorphous maffes, and fometimes alfo cryftallized in fix-fided irregular prifms. Its fracture is conchoidal. Luftre from 2 to 0, Either opaque, or its tranfparency is 1. Hardnefs 9 to 10. Sp. gr. from 2.5 to 2.82. Its colours are various. When heated, it does not decrepitate. It feems to be compofed of filica and alumina, and often alfo contains iron.

Variety 1. Common jafper.

Sp. gr. from 2.58 to 2.7. Its colours are different fhades of white, yellow, red, brown, and green; often variegated, fpotted, or veined, with feveral colours.

Variety 2. Egyptian pebble.

This variety is found chiefly in Egypt. It ufually has a fpheroidal or flat rounded figure, and is enveloped in a coarfe rough cruft. It is opaque. Hardnefs 10. Sp. gr. 2.564. It is chiefly diftinguifhed by the variety of colours, which always exift in the fame fpecimen, either in concentric ftripes or layers, or in dots or dentritical figures. Thefe colours are, different browns and yellows, milk white, and ifabella green; black alfo has been obferved in dots.

Variety 3. Striped jafper.

This variety is alfo diftinguifhed by concentric ftripes or layers of different colours: thefe colours are, yellow, brownifh red, and green. It is diftinguifhed from the laft variety by its occurring in large amorphous maffes, and by its fracture, which is nearly even.

44 Tripoli.

SPECIES 9. Tripoli.

This mineral is found fometimes in an earthy form, but more generally indurated. Its texture is earthy. Its fracture often fomewhat conchoidal Luftre 0. Generally opaque. Hardnefs 4 to 7. Sp. gr. 2.080 to 2.529. Abforbs water. Feel, harfh dry. Hardly adheres to the tongue. Takes no polifh from the nail. Does not ftain the fingers. Colour generally pale yellowifh grey, alfo different kinds of yellow, brown, and white.

It contains, according to Haaffe, 90 parts of filica, 7 alumina, and 3 of iron. A mineral belonging to this fpecies was analyfed by Klaproth, and found to contain

66.5	filica,
7.0	alumina,
2.5	oxide of iron,
1.5	magnefia,
1.25	lime,
19.	air and water.
97.75	

45 G. VI. 1. ASI. Micarell.

GENUS VI. 1. ASI.

SPECIES 1. Micarell *.

This name has been given by Mr Kirwan to a ftone which former mineralogifts confidered as a variety of mica. It is found in granite. Its texture is foliated, and

* *Kirwan's Min.* i. 212.

(x). *Kirwan's Min.* I. 303.—*Baumer, Jour. de Phyf.* II. 154. and *Monnet, ibid.* 331.—*Wiegleb, Crell's Annals*, 1788, p. 45. and 135.

(y) *Kirw. Min.* I. 309.—*Borral Hift. Natur. de Corfe.*—*Henkel Act. Acad. Nat. Curios.* V. 339.

Earths and Stones.

and it may be ſplit into thin plates. Luſtre metallic, 3. Opaque. Hardneſs 6. Sp. gr. 2.980. Colour browniſh black. At 153° Wedgewood, it melts into a black compact glaſs, the ſurface of which is reddiſh *.

* Kirw. ibid.

A ſpecimen analyſed by Klaproth contained

63.00 alumina,
29.50 ſilica,
6.75 iron.

99.25

46 Shorl. † Ibid. i. 265.

SPECIES 2. Shorl †.

No word has been uſed by mineralogiſts with leſs limitation than *ſhorl*. It was firſt introduced into mineralogy by Cronſtedt, to denote any ſtone of a columnar form, conſiderable hardneſs, and a ſpecific gravity from 3 to 3.4. This deſcription applied to a very great number of ſtones. And ſucceeding mineralogiſts, though they made the word more definite in its ſignification, left it ſtill ſo general, that under the deſignation of *ſhorl* almoſt 20 diſtinct ſpecies of minerals were included.

Mr Werner firſt defined the word *ſhorl* preciſely, and reſtricted it to one ſpecies of ſtones. We uſe the word in the ſenſe aſſigned by him.

Shorl is found abundantly in mountains, either maſſive or cryſtallized, in three or nine ſided priſms, often terminated by three ſided ſummits. The ſides of the cryſtals are longitudinally ſtreaked. Its texture is foliated. Its fracture conchoidal. Luſtre 2. Opaque. Hardneſs 10. Sp. gr. 2.92 to 3.212. Colour black. Streak grey. It does not become electric by heat. When heated to redneſs, its colour becomes browniſh red; and at 127° Wedgewood, it is converted into a browniſh compact enamel ‡. According to Wiegleb, it is compoſed of

‡ Ibid. i. 166.

41.25 alumina,
34.16 ſilica,
20.00 iron,
5,41 mangane ſe.

100.82 §

§ Crell's Beiträge, 1. Bandes. 4. Stück, p. 21.

SPECIES 5. Granatite.

Staurotide of Hauy—*Pierre de Croix* of De Liſle—*Staurolithe* of Lametherie.

47 Granatite.

We have adopted from Mr Vauquelin the term *granatite* to denote this ſtone, becauſe all the other names are ambiguous, having been applied to another mineral poſſeſſed of very different properties.

Granatite is found in Galicia in Spain, and Britanny in France. It is always cryſtallized in a very peculiar form; two ſix-ſided priſms interſect each other, either at right angles or obliquely ¶. Hence the name *croſsſtone*, by which it was known in France and Spain *. Mr Hauy has proved, in a very ingenious manner, that the primitive form of the granatite is a rectangular priſm, whoſe baſes are rhombs, with angles of $129\frac{1}{2}$° and $50\frac{1}{2}$°; and that the height of the priſm is to the greater diagonal of a rhomb as 1 to 6; and that its integrant molecules are triangular priſms, ſimilar to what would be obtained by cutting the primitive cryſtal in two, by a plane paſſing vertically through the ſhorter diagonal of the rhomboidal baſe. From this ſtructure he has demonſtrated the law of the formation of the cruciform varieties †. The colour of granatite is greyiſh or reddiſh brown.

¶ Fig. 10. * Romé de Liſle, ii. 435.

† Ann. de Chim. vi. 142.

According to the analyſis of Vauquelin, it is compoſed of

47.06 alumina,
30.59 ſilica,
15.30 oxide of iron,
3.00 lime.

95.95 ‡.

‡ Ibid. xxx. 106.

GENUS VI. 2. SAL.

48 G. VI. 2. SAL. Tourmaline.

SPECIES 4. Tourmaline (z).

This ſtone was firſt made known in Europe by ſpecimens brought from Ceylon; but it is now found frequently forming a part of the compoſition of mountains. It is either in amorphous pieces, or cryſtallized in three or nine ſide priſms, with four-ſided ſummits.

Its texture is foliated: Its fracture conchoidal. Internal luſtre 2 to 3. Tranſparency 3 to 4; ſometimes only 2 (A). Cauſes only ſingle refraction §. Hardneſs 9 to 11. Sp. gr. 3.05 to 3.155. Colour brown, often ſo dark that the ſtone appears black; the brown has alſo ſometimes a tint of green, blue, red, or yellow.

§ Hauy, Jour. de Min. N° xxviii. 265.

When heated to 200° Fahrenheit, it becomes electric; one of the ſummits of the cryſtal negatively, the other poſitively ¶. It reddens when heated; and is fuſible *per ſe* with intumeſcence into a white or grey enamel.

¶ Æpinus.

A ſpecimen of the tourmaline of Ceylon, analyſed by Vauquelin, was compoſed of

40 ſilica,
39 alumina,
12 oxide of iron,
4 lime,
2.5 oxide of mangane ſe,

97.5 *.

* Ann. de Chim. xxx. 105.

SPECIES 5. Argentine felſpar †.

49 Argentine felſpar. † Kirwan, i. 327.

This ſtone was diſcovered by Mr Dodun in the black mountains of Languedoc. It is either amorphous, or cryſtallized in rhomboidal tables, or ſix or eight ſided priſms. Its texture is foliated. Fragments rectangular. Laminæ inflexible. Internal luſtre 4. Tranſparency 2. Colour white; two oppoſite faces of the cryſtals are ſilver white, two others dead white. Hardneſs of the ſilvery laminæ 6, of the reſt 9. Brittle. Sp. gr. 2.5. When the flame of the blow-pipe is directed againſt the edges of the cryſtal (ſtuck upon glaſs), it eaſily melts into a clear compact glaſs; but when the flame is directed againſt the faces, they preſerve their luſtre, and the edges alone ſlowly melt.

According to the analyſis of Dodun, it is compoſed of

46 ſilica,
36 alumina,
16 oxide of iron,

98

When this ſtone is expoſed to the atmoſphere, it is apt

(z) *Kirw.* I. 271.—*Berg.* II. 118. and V. 402.—*Gerhard. Mem. Berlin*, 1777. p. 14.—*Hauy Mem. Par.* 1784, 270.—*Wilſon Phil. Tranſ.* XLI. 308.—*Æpinus. Recueil ſur la Tourmaline.* See alſo *La Porterie. Le Sapphir, l'Oeil de Chat, et la Tourmaline de Ceylon demaſqués.*

(A) And when black only 1.

Earths and Stones.

apt to decay: Its furface becomes iridefcent, and at laft changes to ochre yellow: Its fpecific gravity is 2.3 or 2.212; and when breathed upon, it gives out an earthy fmell.

50 Mica.

SPECIES 6. MICA *.

* Kirw. i. 210—Gmelin, Nov. Com. Petrop. xii. 549.

This ftone forms an effential part of many mountains, and has been long known under the names of *glacies mariæ* and *Mufcovy glafs*. It confifts of a great number of thin laminæ adhering to each other, fometimes of a very large fize. Specimens have been found in Siberia nearly 2½ yards fquare (B).

It is fometimes cryftallized: Its primitive form is a rectangular prifm, whofe bafes are rhombs, with angles of 120° and 60° †: Its integrant molecule has the fame form. Sometimes it occurs in rectangular prifms, whofe bafes alfo are rectangles, and fometimes alfo in a fhort fix-fided prifms ‡; but is much more frequently in plates or fcales of no determinate figure or fize §.

† Fig. 11.

‡ Fig. 12.

§ Hauy, Jour. de Min. N° xxviii. 296.

Its texture is foliated. Its fragments flat. The lamellæ flexible, and fomewhat elaftic. Luftre metallic, from 3 to 4. Tranfparency of the laminæ 3 or 4, fometimes only 2 (C). Hardnefs 6. Very tough. Often abforbs water. Sp. gr. from 2.6546 to 2.9342. Feels fmooth, but not greafy. Powder feels greafy. Colour, when pureft, filver white or grey; but it occurs alfo yellow, greenifh, reddifh, brown, and black. Mica is fufible by the blow-pipe into a white, grey, green, or black, enamel; and this laft is attracted by the magnet (D). Spanifh wax rubbed by it becomes negatively electric ¶.

¶ Ibid.

A fpecimen of mica, analyfed by Vauquelin, contained

50.00	filica,
35.00	alumina,
7.00	oxide of iron.
1.35	magnefia,
1.33	lime,
94.68 *.	

* Ibid. 301.

Mica has long been employed as a fubftitute for glafs. A great quantity of it is faid to be ufed in the Ruffian marine for panes to the cabin windows of fhips; it is preferred, becaufe it is not fo liable as glafs to be broken by the agitation of the fhip.

51 Talc.

SPECIES 7. Talc †.

* Kirw. i. 150—Pott. Mem. Berl. 1746, p. 65.

This ftone has a very ftrong refemblance to mica, and was long confidered as a mere variety of that mineral. It occurs fometimes in fmall loofe fcales, and fometimes in an indurated form; but it has not hitherto been found cryftallized.

Its texture is foliated. The lamellæ are flexible, but not elaftic. Its luftre is from 2 to 4. Tranfparency from 2 to 4. Hardnefs 4 to 6. Sp. gr. when indurated, from 2.7 to 2.8. Feels greafy. Colour moft commonly whitifh or greenifh. Spanifh wax rubbed with it becomes *pofitively* electric ‡.

† Hauy, Jour. de Min. N° xxviii. 291.

Variety 1. Scaly talc.

Talcite of Kirwan.

This variety occurs under the form of fmall fcales, fcarcely cohering. Luftre 3 to 4. Very light. Adheres to the fingers. When rubbed upon the fkin, it gives it a glofs. Colour white, with a fhade of red or green; fometimes leek green.

Simple Stones.

Variety 2. Common talc.

Venetian talc.

This variety often occurs in oblong nodules. Luftre, nearly metallic, 4. Tranfparency 2 to 3; when very thin 4. Hardnefs 4 to 5. Colour white, with a fhade of green or red; or apple green, verging towards filver white. By tranfmitted light green.

Variety 3. Shiftofe talc.

Its ftructure is flaty. Fracture hackly and long fplintery. Eafily crumbles when rubbed in the fracture. External luftre 2 to 3; internal, 1: but fometimes, in certain pofitions, 3. Colour grey, with a fhade of white, green or blue. Becomes white and fcaly when expofed to the air.

A fpecimen of *common talc*, analyfed by Mr Chenevix, contained

48.0	filica,
37.0	alumina,
6.0	oxide of iron,
1.5	magnefia,
1.5	lime,
5.0	water,
99.0 §.	

§ Ann. de Chim. xxviii. 200.

SPECIES 8. Bafaltine ¶.

52 Bafaltine.

Bafaltic hornblende of Werner—*Actinote* of Hauy—*Zillertite* of Lametherie—*Shorl prifmatique hexagone* of Sauffure.

¶ Kirw. i. 219.

This ftone is found commonly in bafaltic rocks; hence its name, which we have borrowed from Mr Kirwan. It is cryftallized, either in rhomboidal prifms, or fix or eight fided prifms, terminated by three-fided pyramids. Its texture is foliated. Its fracture uneven. Luftre 3. Tranfparency, when in very thin plates, 1. Hardnefs from 9 to 10. Sp. gr. 3.333. Colour black, dark green, or yellowifh green. Streak white. Tranfmits a reddifh yellow light. Before the blow-pipe, it melts into a greyifh coloured enamel, with a tint of yellow *. A fpecimen, feemingly of this ftone, analyfed by Bergman, contained

*Le Lievre, Jour. de Min. N° xxviii. 269.

58	filica,
27	alumina,
9	iron,
4	lime,
1	magnefia,
99 †.	

† Berg. iii. 207.

SPECIES 9. Hornblende ‡.

Amphibole of Hauy (E).

53 Hornblende.

This ftone enters into the compofition of various mountains. Its texture is very confpicuoufly foliated. Fracture conchoidal. Fragments often rhomboidal. Luftre 2. Opaque. Hardnefs 5 to 9. Tough. Sp. gr. 2.922 to 3.41. Colour black, blackifh green, olive green,

‡ Kirw. i. 213.

(B) *Hift. General de Voyages*, T. XVIII. 272, quoted by Hauy *Jour. de Min.* N° XXVIII. 299.

(C) Black mica is often nearly opaque.

(D) *Hauy, ibid.* p. 795. Bergman, however, found pure mica infufible *per fe*; and this has been the cafe with all the fpecimens of Mufcovy glafs which we have tried.

(E) We fufpect, that under this name Mr Hauy comprehends *fhorl* alfo.

Earths and Stones.

green, or leek green. Streak greenifh. It neither becomes electric by friction nor heat*. Before the blow-pipe it melts into a black glafs. A fpecimen of black hornblende, analyfed by Mr Hermann, was compofed of

* Hauy, Jour. de Min. No xxviii. 267.

37 filica,
27 alumina,
25 iron,
5 lime,
3 magnefia.

——
97 †

† Beob. der Berlin, 5. Band. 317

54 Refplendent hornblende.

SPECIES 10. Refplendent Hornblende.

There are two minerals which Werner confiders as varieties of hornblende, and Mr. Kirwan as conftituting a diftinct fpecies These till future analyfes decide the point, we fhall place here under the name of refplendent hornblende, the name given them by Mr Kirwan ; and we fhall defcribe them feparately.

Variety 1. Labradore hornblende.

Texture, curved foliated. Luftre, in fome pofitions, o ; in others metallic, and from 3 to 4. Opaque. Hardnefs 8 to 9. Sp. gr. from 3.35 to 3.434. Colour, in moft pofitions, greyifh black ; in others, it reflects a ftrong iron grey, fometimes mixed with copper red.

Variety 2. Shiller fpar ‡.

‡ Kirw. i. 221.

Texture foliated. Luftre metallic, 4. Tranfparency, in thin pieces, 1. Hardnefs 8 to 9. Sp. gr. 2.882. Colour green, often with a fhade of yellow ; alfo golden yellow. In fome pofitions it reflects white, grey, or yellow. At 141 Wedgewood, hardened into a porcelain mafs. A fpecimen, analyfed by Gmelin, was compofed of

43.7 filica,
17 9 alumina,
23.7 iron,
11.2 magnefia.

——
96.5 §

§ Bergbaukunde, 1 Band. p. 92.

It has been found in the Hartz, ftuck in a ferpentine rock.

55. Obfidian.

SPECIES 11. Obfidian *.

* Kirw. i. 264.

Iceland agate.

This ftone is found either in detached maffes, or forming a part of the rocks which compofe many mountains. It is ufually invefted with a grey or opaque cruft. Its fracture is conchoidal. Its internal luftre 3. Tranfparency 1. Hardnefs 10. Sp. gr. 2.348. Colour black or greyifh black; when in very thin pieces, green. It melts into an opaque grey mafs. According to Bergman, it is compofed of

69 filica,
22 alumina,
9 iron.

——
100 †

† Berg. iii. 204.

56 Petrilite.

SPECIES 12. Petrilite ‡.

‡ Kirw. i. 325.

Cubic felfpar.

This ftone is found in the mafs of mountains. It is amorphous. Texture foliated. Fracture fplintery. Fragments cubic, or inclining to that form ; their faces unpolifhed. Luftre 2. Tranfparency partly 2, partly 1. Hardnefs 9. Sp. gr. 3.081. Colour reddifh brown. Does not melt at 160° Wedgewood.

57 Felfite

SPECIES 13. Felfite §.

§ Kirw. i. 326.

Compact felfpar.

This ftone alfo forms a part of many mountains, and is amorphous. Texture fomewhat foliated. Fracture uneven, approaching to the fplintery. Luftre 1. Tranfparency fcarce 1. Hardnefs 9. Colour azure blue, and fometimes brown and green Streak white. Before the blow-pipe, whitens and becomes rifty ; but is infufible *per fe*.

Simple Stones.

58 G. VII. SAP. Felfpar.

GENUS VII. SAP.

SPECIES 1. Felfpar *.

* Kirw. i. 310. and Jour de Phyf. paffim.

This ftone forms the principal part of many of the higheft mountains. It is commonly cryftallized. Its primitive form, according to De Lifle, is a rectangular prifm, whofe bafes are rhombs, with angles of 65° and 115†°. Sometimes the edges of the prifm are wanting, and faces in their place ; and fometimes this is the cafe alfo with the acute angles of the rhomb. For a defcription and figure of thefe, and other varieties, we refer the reader to *Romé de Lifle*‡, *Mr Hauy* §, and *Mr Pini* *.

† Fig. 13. and 14.

‡ Cryftall. ii. 401.

§ Mem. Par. 1784, p 273.

* Sur de Nouvelle Cbryftallifation, &c. 8.

Its texture is foliated. Its crofs fracture uneven. Fragments rhomboidal, and commonly fmooth and polifhed on four fides. Luftre of the polifhed faces often 3. Tranfparency from 3 to 1. Hardnefs 9 to 10. Sp. gr. from 2.437 to 2.7. Gives a peculiar odour when rubbed. It is made electric with great difficulty by friction. Fufible *per fe* into a more or lefs tranfparent glafs. When cryftallized, it decrepitates before the blow-pipe.

Variety 1. Pure Felfpar.

Moon ftone—Adularia.

This is the pureft felfpar hitherto found. It occurs in Ceylon and Switzerland ; and was firft mentioned by Mr Sage. Luftre nearly 3. Tranfparency 2 to 3. Hardnefs 10. Sp. gr. 2.559. Colour white ; fometimes with a fhade of yellow, green, or red. Its furface is fometimes iridefcent.

Variety 2. Common Felfpar.

Luftre of the crofs fracture o ; of the fracture, in the direction of the laminæ, from 3 to 1. Tranfparency 2 to 1. Colour moft commonly flefh red ; but often bluifh grey, yellowifh white, milk white, brownifh yellow ; and fometimes blue, olive green, and even black.

Variety 3. Labradore felfpar.

This variety was difcovered on the coaft of Labradore by Mr Wolfe ; and fince that time it has been found in Europe. Luftre 2 to 3. Tranfparency from 1 to 3. Sp. gr. from 2.67 to 2 6925. Colour grey. In certain pofitions, fpots of it reflect a blue, purple, red, or green colour.

Variety 4. Continuous felfpar.

This variety moft probably belongs to a different fpecies ; but as it has not hitherto been analyfed, we did not think ourfelves at liberty to alter its place.

It is found in large maffes. Texture earthy. Fracture uneven, fometimes fplintery Luftre o. Tranfparency 1. Hardnefs 10. Sp gr. 2.609. Colour reddifh grey, reddifh yellow, flefh red.

A fpecimen of green felfpar from Siberia, analyfed by Vauquelin, contained

62.83 filica,
17.02 alumina,
16.00 potafs,
3.00 lime,
1.00 oxide of iron.

——
99.85†

† Ann. de Chim. xxx.

59 Lepidolite.

SPECIES 2. Lepidolite (F).

Lilalite.

This ftone appears to have been firft obferved by the Abbé Poda, and to have been firft defcribed by De Born *. Hitherto it has only been found in Moravia in Germany, and Sudermania in Sweden †. There it is mixed with granite in large amorphous maffes. It is compofed of thin plates, eafily feparated, and not unlike thofe of mica ‡ Luftre, pearly 3. Tranfparency between 1 and 2. Hardnefs 4 to 5. Not eafily pulverifed §. Sp. gr. from 2.816 * to 2.8549 †. Colour of the mafs, violet blue; of the thin plates, filvery white. Powder white, with a tint of red ‡ Before the blowpipe, it froths, and melts eafily into a white femitranfparent enamel, full of bubbles. Diffolves in borax with effervefcence, and communicates no colour to it §. Effervefces flightly with foda, and melts into a mafs fpotted with red. With microcofmic falt, it gives a pearl coloured globule *.

* *Crell's Annals*, 1791, ii. 196.
† *Beyer, Ann. de Chim.* xxix. 108.
‡ *Le Lievre, Jour. de Min.* N° li. 219
§ *Ibid.*
* *Klaproth*
† *Hauy*
‡ *Le Lievre, Jour de Min.* N° li. 219.
§ *Ibid.*
* *Klaproth, Ann. de Chim.* xxii. 37.

This ftone was firft called lilalite from its colour, that of the *lily*. Klaproth, who difcovered its component parts, gave it the name of *lepidolite* (G).

It is compofed of
53 filica,
20 alumina,
18 potafs,
5 fluat of lime,
3 oxide of manganefe,
1 oxide of iron.

100 †

† *Vauquelin, Ann. de Chim.* xxx. 105.

60 Leucite.

SPECIES 3. Leucite ‡

Vefuvian of Kirwan—*White Garnet* of Vefuvius.

This ftone is ufually found in volcanic productions, and is very abundant in the neighbourhood of Vefuvius. It is always cryftallized. The primitive form of its cryftals is either a cube or a rhomboidal dodecahedron, and its integrant molecules are tetrahedrons; but the varieties hitherto obferved are all polyhedrons: The moft common has a fpheroidal figure, and is bounded by 24 equal and fimilar trapeziods §; fometimes the faces are 12, 18, 36, 54, and triangular, pentagonal, &c. For a defcription and figure of feveral of thefe, we refer the reader to Mr Hauy *. The cryftals vary from the fize of a pin-head to that of an inch.

‡ *Kirw.* i. 285.
§ Fig. 15.
* *Jour. de Min.* N° xxvii. 185.

The texture of the leucite is foliated. Its fracture fomewhat conchoidal. Luftre 3; when in a ftate of decompofition 0. Tranfparency 3 to 2; when decompofing 0. Hardnefs 8 to 10; when decompofing 5 to 6. Sp. gr. 2.4648. Colour white, or greyifh white (H). Its powder caufes fyrup of violets to affume a green colour †. It is compofed, as Klaproth has fhewn, of
54 filica,
23 alumina,
22 potafs,

99 (I)

† *Vauquelin, Jour. de Min.* N° xxxix. 165.

It was by analyfing this ftone that Klaproth difcovered the prefence of potafs in the mineral kingdom; which is not the leaft important of the numerous difcoveries of that accurate and illuftrious chemift.

Leucite is found fometimes in rocks which have never been expofed to volcanic fire; and Mr. Dolomieu has rendered it probable, from the fubftances in which it is found, that the leucite of volcanoes has not been formed by volcanic fire, but that it exifted previoufly in the rocks upon which the volcanoes have acted, and that it was thrown out unaltered in fragments of thefe rocks ‡.

‡ *Jour. de Min.* N° xxxix. 177.

GENUS VIII. SAG.

61 G.VIII.SAG Emerald.

SPECIES 1. Emerald (K).

This ftone has hitherto been only found cryftallized. The primitive form of its cryftals is a regular fix-fided prifm; and the form of its integrant molecules is a triangular prifm, whofe fides are fquares, and bafes equilateral triangles §. The moft common variety of its cryftals is the regular fix-fided prifm, fometimes with the edges of the prifm or of the bafes, or the folid angles, or both wanting *, and fmall faces in their place †. The fides of the prifm are generally channelled.

§ *Hauy, Jour. de Min.* N° xix. 72
* Fig. 16.
† *Romé de Lifle*, ii. 245. and *Hauy, ibid.*

Its texture is foliated. Its fracture conchoidal. Luftre ufually from 3 to 4. Tranfparency from 2 to 4. Caufes a double refraction. Hardnefs 12. Sp. gr. 2.65 to 2.775. Colour green. Becomes electric by friction, but not by heat. Its powder does not phofphorefce when thrown on a hot iron ‡. At 150° Wedgewood it melts into an opaque coloured mafs. According to Dolomieu, it is fufible *per fe* by the blow-pipe *.

‡ *Dolomieu. Jour. de Min.* N° xviii. 19.
* *Ibid.*

This mineral was formerly fubdivided into two diftinct fpecies, the *emerald*, and *beryl* or *aqua marina*. Hauy demonftrated, that the emerald and beryl correfponded exactly in their ftructure and properties, and Vauquelin found that they were compofed of the fame ingredients; henceforth, therefore, they muft be confidered as varieties of the fame fpecies.

The variety formerly called *emerald* varies in colour from the pale to the perfect green. When heated to 120° Wedgewood, it becomes *blue*, but recovers its colour when cold. A fpecimen, analyfed by Vauquelin, was compofed of
64.60 filica,
14.00 alumina,
13.00 glucina,
3.50 oxide of chromum,
2.56 lime,
2.00 moifture or other volatile ingredient.

99.66 †

† *Ann. de Chim.* xxvi. 264.

The *beryl* is of a greyifh green colour, and fometimes blue, yellow, and even white: fometimes different colours appear in the fame ftone ‡ It is found in Ceylon, different parts of India, Brazil, and efpecially in Siberia and Tartary, where its cryftals are fometimes a foot long §.

‡ *Dolomieu, ibid.*
§ *Ibid.*

(F) *Kirw.* I. 208.—*Karften. Beob. der Berlin*, 5 *Band.* 71.—*Klaproth Beiträge*, I. 279. *and* II. 191.

(G) That is, *fcale ftone*, or ftone compofed of fcales: From λεπις *the fcale of a fifh*, and λιθος *a ftone.*

(H) Hence the name leucite, from λευκος, *white.*

(I) See *Jour. de Min.* N° XXVII. 164. and 201. and *Klaproth's Beiträge*, II. 39.

(K) *Kir.* I. 247. and 248.—*Dolomieu. Magazin Encyclopædique*, II. 17. and 145.; and *Jour de Min.* N° XVIII. 19.—*Klaproth Beiträge*, II.

Earths and Stones.

long. A specimen of beryl, analysed by Vauquelin, contained

69	silica,
13	alumina,
16	glucina,
1.5	oxide of iron.
99.5 *	

* Ann. de Chim. xxviii. 168.

It was by analysing this stone that Vauquelin discovered the earth which he called *glucina*.

62 G. IX. SAB Staurolite.

Genus IX. sab.

Species 1. Staurolite †.

† Kirw. i. 282.

Andreolite of Lametherie and Hauy—*Hyacinthe blanche cruciforme*, var. 9 of Romé de Lisle.

This stone has been found at Andreasberg in the Hartz. It is crystallized, and the form of its crystals has induced mineralogists to give it the name of *cross-stone*. Its crystals ‡ are two four-sided flattened prisms, terminated by four sided pyramids, intersecting each other at right angles: the plane of intersection passing longitudinally through the prisms (L).

‡ Fig. 17.

Its texture is foliated. Its lustre waxy, 2. Transparency from 1 to 3. Hardness 9. Brittle. Sp. gr. 2.355 to 2.361. Colour milk white. When heated slowly, it loses 0.15 or 0.16 parts of its weight, and falls into powder. It effervesces with borax and microcosmic salt, and is reduced to a greenish opaque mass. With soda it melts into a frothy white enamel. When its powder is thrown on a hot coal, it emits a greenish yellow light §.

§ Hauy, Jour. de Min. N° xxviii. 280.

A specimen analysed by Westrum was composed of

44	silica,
20	alumina,
20	barytes,
16	water.
100	

Klaproth found the same ingredients, and nearly in the same proportions *.

* Beiträge, ii. 80.

A variety of staurolite has been found only once, which has the following peculiarities.

Its lustre is pearly, 2. Sp. gr. 2.361. Colour brownish grey. With soda it melts into a purplish and yellowish frothy enamel. It is composed, according to Westrum, of

47.5	silica,
12.0	alumina,
20.0	barytes,
16.0	water,
4.5	oxides of iron and manganese.
100.0	

63 G. X. ASL. Chrysoberyl.

Genus X. 1. asl.

Species 1. Chrysoberyl †.

† Kirw. i. 261.

Oriental chrysolite of jewellers—*Cymophane* of Hauy.

Hitherto this stone has been found only in Brazil, the island of Ceylon, and as some affirm near Nortschink in Siberia. Werner first made it a distinct species, and gave it the name which we have adopted. It is usually found in round masses about the size of a pea, but it is sometimes also crystallized. The primitive form of its crystals is a four-sided rectangular prism, whose height is to its breadth as $\sqrt{3}$ to 1, and to its thickness as $\sqrt{2}$ to 1 *. The only variety hitherto observed is an eight-sided prism, terminated by six-sided summits †. Two of the faces of the prism are hexagons, two are rectangles, and four trapeziums; two faces of the summits are rectangles, and the other four trapeziums. Sometimes two of the edges of the prism are wanting, and small faces in their place ‡.

Simple Stones.

* Fig. 18.
† Fig. 19.
‡ Hauy, Jour. de Min. N° xxi. 5.

Its texture is foliated. Laminæ parallel to the faces of the prism. Lustre 3 to 4. Transparency 3 to 4. Causes single refraction. Hardness 12. Sp. gr. from 3.698 § to 3.7961 *. Colour yellowish green, surface sparkling. It is infusible by the blow-pipe *per se*, and with soda.

§ Werner.
* Hauy.

A specimen of chrysoberyl, analysed by Klaproth, was composed of

71.5	alumina,
18.0	silica,
6.0	lime,
1.5	oxide of iron.
97.0 †	

† Beiträge.

64 G. X. 2. SAL. Hyalite.

Genus X. 2. sal.

Species 2. Hyalite *.

* Kirw. i. 296.

This stone is frequently found in trap. It occurs in grains, filaments, and rhomboidal masses. Texture foliated. Fracture uneven, inclining to conchoidal. Lustre glassy (M), 2 to 3. Transparency 2 to 3; sometimes, tho' seldom, it is opaque. Hardness 9. Sp. gr. 2.11 †. Colour pure white. Infusible at 150° Wedgewood; but it yields to soda ‡. According to Mr Link, it is composed of

† Kirwan.
‡ Id.

57	silica,
18	alumina,
15	lime.
90	and a very little iron §.

§ Crell's Annals, 1790. 2 Band. 232.

65 Ædelite.

Species 3. Ædelite *.

This stone has hitherto been found only in Sweden at Mosseberg and Ædelfors. From this last place Mr Kirwan, who first made it a distinct species, has given it the name which we have adopted. It was first mentioned by Bergman †. Its form is tuberose and knotty. Texture striated; sometimes resembles quartz. Lustre from 0 to 1. Sp. gr. 2.515 after it has absorbed water ‡. Colour light grey, often tinged red; also yellowish brown, yellowish green, and green. Before the blow-pipe it intumesces and forms a frothy mass. Acids convert it into a jelly §. A specimen from Mosseberg, analysed by Bergman, contained

* Kirw. i. 276.
† Opusc. vi. 101.
‡ See Kirwan's Min. i. 276.
§ Berg. iii. 227.

69	silica,
20	alumina,
8	lime,
3	water.
100 *	

* Opusc. vi. 101.

A specimen from Ædelfors yielded to the same chemist

62	silica,
18	alumina,
17	lime,
4	water.
100 †	

† Ibid.

(L) See *Gillot*, *Jour. de Phys.* 1793, p. 1 and 2.

(M) Hence probably the name *hyalite*, which was imposed by Werner from ὕαλις, and λιθος, *a stone*.

Earths and Stones.

GENUS X. 3. SAWL.

SPECIES 4. Zeolite (N).

66 G. X. 3. SAWL. Zeolite.

This ſtone was firſt deſcribed by Cronſtedt in the Stockholm Tranſactions for 1756. It is found ſometimes amorphous and ſometimes cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are ſquares. The moſt common variety is a long four-ſided priſm, terminated by low four-ſided pyramids*.

* Hauy, Jour. de Min. N° xiv. 86.

Its texture is ſtriated or fibrous. Its luſtre is ſilky, from 3 to 1. Tranſparency from 2 to 4; ſometimes 1. Hardneſs 6 to 8; ſometimes only 4. Abſorbs water. Sp gr. 2.07 to 2.3. Colour white, often with a ſhade of red or yellow; ſometimes brick red, green, blue. When heated, it becomes electric like the tourmaline †. Before the blow-pipe it froths (O), emits a phoſphoreſcent light, and melts into a white ſemitranſparent enamel, too ſoft to cut glaſs, and ſoluble in acids. In acids it diſſolves ſlowly and partially without efferveſcence; and at laſt, unleſs the quantity of liquid be too great, it is converted into a jelly.

† Hauy, ibid N° xxviii. 276.

A ſpecimen of zeolite (P), analyſed by Vauquelin, contained

53.00	ſilica,
27.00	alumina,
9.46	lime,
10.00	water.
99.46 ‡.	

‡ Ibid. N° xliv. 576.

SPECIES 5. Stilbite.

67 Stilbite.

This ſtone was firſt formed into a diſtinct ſpecies by Mr Hauy. Formerly it was conſidered as a variety of zeolite.

The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are rectangles. It cryſtallizes ſometimes in dodecahedrons, conſiſting of a four ſided priſm with hexagonal faces, terminated by four-ſided ſummits, whoſe faces are oblique parallelograms; ſometimes in ſix-ſided priſms, two of whoſe ſolid angles are wanting, and a ſmall triangular face in their place *.

* Hauy, Jour. de Min. N° xiv. 86.

Its texture is foliated. The laminæ are eaſily ſeparated from each other; and are ſomewhat flexible. Luſtre pearly, 2 or 3 (Q). Hardneſs inferior to that of zeolite, which ſcratches ſtilbite. Brittle. Sp. gr. 2.500†. Colour pearl white. Powder bright white, ſometimes with a ſhade of red. This powder, when expoſed to the air, cakes and adheres as if it had abſorbed water. It cauſes ſyrup of violets to aſſume a green colour. When ſtilbite is heated in a porcelain crucible, it ſwells up and aſſumes the colour and ſemitranſparency of baked porcelain. By this proceſs it loſes 0.185 of its weight. Before the blow-pipe it froths like borax, and then melts into an opaque white-coloured enamel ‡.

† Hauy, ibid. N° xxviii. 276.

‡ Vauquelin, ibid. N° xxxix. 161.

According to the analyſis of Vauquelin, it is compoſed of

Simple Stones.

52.0	ſilica,
17.5	alumina,
9.0	lime,
18.5	water.
97.0 *	

* Ibid. 164.

SPECIES 6. Analcime.

68 Analcime.

This ſtone, which was diſcovered by Mr Dolomieu, is found cryſtallized in the cavities of lava. It was firſt made a diſtinct ſpecies by Mr Hauy. Mineralogiſts had formerly confounded it with zeolite.

The primitive form of its cryſtals is a cube. It is ſometimes found cryſtallized in cubes, whoſe ſolid angles are wanting, and three ſmall triangular faces in place of each; ſometimes in polyhedrons with 24 faces. It is uſually ſomewhat tranſparent. Hardneſs about 8; ſcratches glaſs ſlightly. Sp. gr. above 2. When rubbed, it acquires only a ſmall degree of electricity, and with difficulty (R). Before the blow-pipe it melts without frothing, into a white ſemitranſparent glaſs†.

† Hauy, Jour. de Min. N° xiv. 86. and xxviii. 278.

GENUS X. 4. SLA.

SPECIES 7. Lazulite ‡.

69 G.X. 4. SLA. Lazulite.

This ſtone, which is found chiefly in the northern parts of Aſia, has been long known to mineralogiſts by the name of *lapis lazuli*. This term has been contracted into *lazulite* by Mr Hauy; an alteration which was certainly proper, and which therefore we have adopted.

‡ Kirw. i. 283.

Lazulite is always amorphous. Its texture is earthy. Its fracture uneven. Luſtre 0. Opaque, or nearly ſo. Hardneſs 8 to 9. Sp. gr. 2.76 to 2.945 *. Colour blue (S); often ſpotted white from ſpecks of quartz, and yellow from particles of pyrites.

* Briſſon.

It retains its colour at 100° Wedgewood; in a higher heat it intumeſces, and melts into a yellowiſh black maſs. With acids it efferveſces a little, and if previouſly calcined, forms with them a jelly.

Margraff publiſhed an analyſis of lazulite in the Berlin Memoirs for 1758. His analyſis has ſince been confirmed by Klaproth, who found a ſpecimen of it to contain

46.0	ſilica,
14.5	alumina,
28.0	carbonat of lime,
6.5	ſulphat of lime,
3.0	oxide of iron,
2.0	water.
100.0 †	

† Beiträge, i. 196.

GENUS XI. SALI.

SPECIES 1. Garnet (T).

70 G.XI. SALI. Garnet.

This ſtone is found abundantly in many mountains. It is uſually cryſtallized. The primitive form of its cryſtals

(N) *Kirw.* I. 278.—*Guettard*, IV. 637.—*Bucquet*, *Mem. Sav. Etrang.* IX. 576.—*Pelletier*, *Jour. de Phyſ.* XX. 420.

(O) Hence the name *zeolite*, given to this mineral by Cronſtedt; from *ζεω, to ferment, λιθος, a ſtone.*

(P) Dr Black was accuſtomed to mention, in the courſe of his lectures, that Dr Hutton had diſcovered *ſoda* in zeolite. This diſcovery has not hitherto been verified by any other chemical mineralogiſt.

(Q) Hence the name given to this mineral by Hauy, *ſtilbite*, from *στιλβω, to ſhine.*

(R) Hence the name *analcime* given it by Hauy, from *αναλκις, weak.*

(S) Hence the name *lazulite*, from an Arabian word *azul*, which ſignifies *blue*.

(T) *Kirw.* I. 258.—*Gerhard*, *Diſquiſitio phyſico-chymica Granatorum*, &c.—*Paſumot*, *Jour. de Phyſ.* III. 442.—*Wiegleb*, *Ann. de Chim.* I. 231.

Earths and Stones.

crystals is a dodecahedron whose sides are rhombs, with angles of 78° 31′ 44″, and 120° 28′ 16″. The inclination of the rhombs to each other is 120°. This dodecahedron may be considered as a four-sided prism, terminated by four-sided pyramids *. It is divisible into four parallelopipeds, whose sides are rhombs; and each of these may be divided into four tetrahedrons, whose sides are isosceles triangles, equal and similar to either of the halves into which the rhomboidal faces of the dodecahedron are divided by their shorter diagonal. The integrant molecules of garnet are similar tetrahedrons †. Sometimes the edges of the dodecahedrons are wanting, and small faces in their place; and sometimes garnet is crystallized in polyhedrons, having 24 trapezoidal faces. For a description and figure of these, and other varieties of garnet, we refer to *Romé de Lisle* and *Hauy* ‡.

* Fig. 20. * *De Lisle*, ii 322. and *Hauy, Ann. de Chim.* xvii. 305.

† *Hauy, ibid.* 306.

‡ *Ibid.*

The texture of garnet, as Bergman first shewed, is foliated §. Its fracture commonly conchoidal. Internal lustre from 4 to 2. Transparency from 2 to 4; sometimes only 1 or 0. Causes single refraction ‖. Hardness from 10 to 14. Sp. gr. 3.75 to 4.188. Colour usually red. Often attracted by the magnet. Fusible *per se* by the blow-pipe.

§ *Opusc.* ii. 9.

‖ *Hauy, Jour de Min* N° xxviii. 260.

Variety 1. Oriental garnet (u).

Internal lustre 3 to 4. Transparency 4. Hardness 13 to 14. Sp. gr. 4 to 4.188. Colour deep red, inclining to violet (x).

Variety 2. Common garnet.

Fracture uneven, inclining to the conchoidal. Internal lustre 2 to 3. Transparency from 3 to 0. Hardness 10 to 11; sometimes only 9. Sp. gr. 3.75 to 4. Colour commonly deep red, inclining to violet; sometimes verging towards black or olive; sometimes leek green, brown, yellow.

Variety 3. Amorphous garnet.

Structure slaty. Lustre 2. Transparency 2 to 1. Hardness 11 to 12. Sp. gr. 3.89. Colour brownish or blackish red. Found in Sweden, Switzerland, and the East Indies.

A specimen of oriental garnet, analysed by Klaproth, contained

35.75 silica,
27.25 alumina,
36.00 oxide of iron,
0.25 oxide of manganese.
———
99.25 *

* *Beiträge*, ii. 26.

A specimen of red garnet, analysed by Vauquelin, contained

52.0 silica,
20.0 alumina,
17.0 oxide of iron,
7.7 lime.
———
96.7 †

† *Jour. de Min.* N° xliv. 575.

A specimen of black garnet yielded to the same chemist

43 silica,
16 alumina,
20 lime,
16 oxide of iron,
4 moisture.
———
99 ‡

‡ *Ibid.* 573.

Mr Klaproth found a specimen of Bohemian garnet, composed of

40.00 silica,
28.50 alumina,
16.50 oxide of iron,
10.00 magnesia,
3.50 lime,
.25 oxide of manganese.
———
98.75 *

Simple Stones.

* *Beiträge*, ii. 21.

SPECIES 2. Thumerstone †.

71 Thumerstone.

Yanolite of Lamatherie—*Axinite* of Hauy.

This stone was first described by Mr Schreber, who found it near Balme d'Auris in Dauphiné, and gave it the name of *shorl violé* ‡. It was afterwards found near Thum in Saxony, in consequence of which Werner called it *thumerstone*.

† *Kirw.* i. 7.—*Pelletier, Journ. de Phys.* xxvi. 66.

‡ *De Lisle*, ii. 353.

It is sometimes amorphous; but more commonly crystallized. The primitive form of its crystals is a rectangular prism, whose bases are parallelograms with angles of 101° 32′ and 78° 28′ §. The most usual variety is a flat rhomboidal parallelopiped, with two of its opposite edges wanting, and a small face in place of each ‖. The faces of the parallelopiped are generally streaked longitudinally ¶.

§ *Hauy, Jour. de Min.* N° xxviii. 264.

‖ Fig. 21.

¶ *De Lisle, ibid.*

The texture of thumerstone is foliated. Its fracture conchoidal. Lustre 2. Transparency, when crystallized, 3 to 4; when amorphous, 2 to 1. Causes simple refraction *. Hardness 10 to 9. Sp. gr. 3.2956. Colour clove brown; sometimes inclining to red, green, grey, violet, or black. Before the blow-pipe it froths like zeolite, and melts into a hard black enamel. With borax it exhibits the same phenomena, or even when the stone is simply heated at the end of a pincer †.

* *Hauy, ibid.*

† *Vauquelin, Jour de Min.* N° xxiii. 1.

A specimen of thumerstone, analysed by Klaproth, contained

52.7 silica,
25.6 alumina,
9.4 lime,
9.6 oxide of iron with a trace of manganese.
———
97.3 ‡

‡ *Beiträge*, ii. 126.

A specimen, analysed by Vauquelin, contained

44 silica,
18 alumina,
19 lime,
14 oxide of iron,
4 oxide of manganese.
———
99 §

§ *Jour. de Min. ibid.*

SPECIES 3. Prehnite (y).

72 Prehnite.

Though this stone had been mentioned by Sage ‖, Romé de Lisle ¶, and other mineralogists, Werner was the first who properly distinguished it from other minerals, and made it a distinct species. The specimen which he examined was brought from the Cape of Good Hope by Colonel Prehn; hence the name *prehnite*, by which he distinguished it. It was found near Dunbarton by Mr Grotche *; and since that time it has been observed in other parts of Scotland.

‖ *Miner.* i. 232.

¶ *Crystallog.* ii. 275.

* *Ann. de Chim.* xx 13

It

(u) This seems to be the *carbuncle* (ανθραξ) of Theophrastus, and the *carbunculus garamanticus* of other ancient writers. See *Hill's Theophrastus*, περι λιθων, p. 74. and 77.

(x) Hence, according to many, the name *garnet* (in Latin *granatus*), from the resemblance of the stone in colour to the blossoms of the pomegranate.

(y) *Kirw.* I. 274.—*Hassenfratz, Jour. de Phys.* XXXII. 81.—*Sage, ibid.* XXXIV. 446.—*Klaproth. Beob. der Berlin*, 2 *Band.* 211. And *Ann. de Chim.* I. 201.

Earths and Stones.

It is both amorphous and cryſtallized. The cryſtals are in groups, and confuſed: they ſeem to be four-ſided priſms with dihedral ſummits *. Sometimes they are irregular ſix-ſided plates, and ſometimes flat rhomboidal parallelopipeds.

* Hauy, Jour. de Min. N° xxviii. 277.

Its texture is foliated. Fracture uneven. Internal luſtre pearly, ſcarcely 2. Tranſparency 3 to 2. Hardneſs 9 to 10. Brittle. Sp. gr. 2.6969 †. Colour apple green, or greeniſh grey. Before the blow-pipe it froths more violently than zeolite, and melts into a brown enamel. A ſpecimen of prehnite, analyſed by Klaproth, was compoſed of

† Hauy, ibid.

43.83	ſilica,
30.33	alumina,
18.33	lime,
5.66	oxide of iron,
1.16	air and water.
99.31 ‡	

‡ Ann. de Chim. i. 208.

Whereas Mr Haſſenfratz found in another ſpecimen

50.0	ſilica,
20.4	alumina,
23.3	lime,
4.9	iron,
.9	water,
.5	magneſia.
100.0 §	

§ Ibid. and Jour. de Phyſ. N° xxxii. 81.

73
Thallite.

SPECIES 4. Thallite.

Green ſhorl of Dauphiné of De Liſle ||.—*Delphinite* of Sauſſure.

|| Cryſtallog. ii. 401.

This ſtone is found in the fiſſures of mountains; and hitherto only in Dauphiné and on Chamouni in the Alps.

It is ſometimes amorphous, and ſometimes cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are rhombs with angles of 114° 37′, and 65° 23′ ¶. The moſt uſual variety is an elongated four-ſided priſm (often flattened), terminated by four-ſided incomplete pyramids *; ſometimes it occurs in regular ſix-ſided priſms †. The cryſtals are often very ſlender.

¶ Hauy, Jour. de Min. N° xxviii. 271.

* Fig. 22.

† Romé de Liſle, ibid. and Hauy, Jour. de Min. N° xxx. 415.

Its texture appears fibrous. Luſtre inconſiderable. Tranſparency 2 to 3, ſometimes 4; ſometimes nearly opaque. Cauſes ſingle refraction. Hardneſs 9 to 10. Brittle. Sp. gr. 3.4529 to 3.46. Colour dark green (z). Powder white or yellowiſh green, and feels dry. It does not become electric by heat. Before the blow-pipe, froths and melts into a black ſlag. With borax melts into a green bead ‡.

‡ Hauy, and Deſcotils, ibid.

A ſpecimen of thallite, analyſed by Mr Deſcotils, contained

37	ſilica,
27	alumina,
17	oxide of iron,
14	lime,
1.5	oxide of mangancſe.
96.5 §	

§ Ibid. N° xxx. 420.

Simple Stones.

GENUS XII. I. AMS.

SPECIES I. Cyanite *.

Sappare of Sauſſure.

74
G.XII.AMS.
Cyanite.

This ſtone was firſt deſcribed by Mr Sauſſure the ſon, who gave it the name of *ſappare* †. It is commonly found in granite rocks. The primitive form of its cryſtals is a four-ſided oblique priſm, whoſe ſides are inclined at an angle of 103°. The baſe forms with one ſide of the priſm an angle of 103°; with another an angle of 77°. It is ſometimes cryſtallized in ſix-ſided priſms ‡.

* Kirw. i. 209.—Sage, Jour. de Phyſ. xxxv. 39.

† Jour. de Phyſ. xxxiv. 213.

‡ Hauy, Jour. de Min. N° xxviii. 282.

Its texture is foliated. Laminæ long. Fragments long, ſplintery. Luſtre pearly, 2 to 3. Tranſparency of the laminæ 3. Cauſes ſingle refraction §. Hardneſs 6 to 9. Brittle. Sp. gr. from 3.092 to 3.622 ||. Feels ſomewhat greaſy. Colour milk white, with ſhades of ſky or pruſſian blue (A); ſometimes bluiſh grey; ſometimes partly bluiſh grey, partly yellowiſh or greeniſh grey.

§ Hauy, ibid.

|| Kirwan.

Before the blow-pipe it becomes almoſt perfectly white; but does not melt. According to the analyſis of Sauſſure, it is compoſed of

66.92	alumina,
13.25	magneſia,
12.81	ſilica,
5.48	iron,
1.71	lime.
100.17 *	

* Jour. de Phyſ. ibid.

Cyanite has alſo been analyſed by Struvius and Hermann, who agree with Sauſſure as to the ingredients; but differ widely from him and one another as to the proportions.

Struvius.	Hermann.	
5.5	30	alumina,
30.5	39	magneſia,
51.5	23	ſilica,
5.0	2	iron,
4.0	3	lime.
96.5 †	97 ‡	

† Crell's Annals, 1790.

‡ Ibid.

GENUS XII. 2. MSA.

SPECIES 2. Serpentine (B).

75
G. XII. 2.
MSA.
Serpentine.

This ſtone is found in amorphous maſſes. Its fracture is ſplintery. Luſtre 0. Opaque. Hardneſs 6 to 7. Sp. gr. 2.2645 to 2.709. Feels rather ſoft, almoſt greaſy. Generally emits an earthy ſmell when breathed upon. Its colours are various ſhades of green, yellow, red, grey, brown, blue: commonly one or two colours form the ground, and one or more appear in ſpots or veins (c).

Before the blow-pipe it hardens and does not melt.

A ſpecimen of ſerpentine, analyſed by Mr Chenivix, contained

34.5	magneſia,
28.0	ſilica,
23.0	alumina,
4.5	oxide of iron,
0.5	lime,
10.5	water.
101.0 §	

§ Ann. de Chim. xxviii. 199.

GENUS

(z) Hence the name *thallite* given it by Lametherie, from θαλλος, *a green leaf.*

(A) Hence the name *cyanite*, impoſed by Werner.

(B) *Kirw.* I. 156.—*Margraf, Mem. Berlin*, 1759, p. 3.—*Bayen, Jour. de Phyſ.* XIII. 46.—*Mayer, Crell's Annals*, 1789, II. 416.

(c) Hence the name *ſerpentine*, given to the ſtone from a ſuppoſed reſemblance in colours to the ſkin of a ſerpent.

Earths and Stones.

Simple Stones.

GENUS XIII. MSAI.

76 G. XIII. MSAI. Potſtone. *Kirw.* i. 55.

SPECIES 1. Potſtone *.

This ſtone is found in neſts and beds, and is always amorphous. Its ſtructure is often ſlaty. Texture undulatingly foliated. Luſtre from 1 to 3. Tranſparency from 1 to 0; ſometimes 2. Hardneſs 4 to 6. Brittle. Sp. gr. from 2.8531 to 3.023. Feels greaſy. Sometimes abſorbs water. Colour grey with a ſhade of green, and ſometimes of red or yellow; ſometimes leek green; ſometimes ſpecked with red.

Potſtone is not much affected by fire; and has therefore been made into utenſils for boiling water; hence its name.

According to Wiegleb, the potſtone of Como contains

38	magneſia,
38	ſilica,
7	alumina,
5	iron,
1	carbonat of lime,
1	fluoric acid.
90	

77 Chlorite. *Kirw.* i. 47.

SPECIES 2. Chlorite †.

This mineral enters as an ingredient into different mountains. It is ſometimes amorphous, and ſometimes cryſtallized in oblong, four-ſided, acuminated cryſtals.

Its texture is foliated. Its luſtre from 0 to 2. Opaque. Hardneſs from 4 to 6; ſometimes in looſe ſcales. Colour green.

Variety 1. Farinaceous chlorite.

Compoſed of ſcales ſcarcely cohering, either heaped together, or inveſting other ſtones. Feels greaſy. Gives an earthy ſmell when breathed on. Difficult to pulveriſe. Colour graſs green; ſometimes greeniſh brown; ſometimes dark green, inclining to black. Streak white. When the powder of chlorite is expoſed to the blow-pipe it becomes brown. Before the blow-pipe, farinaceous chlorite froths and melts into a dark brown glaſs; with borax it forms a greeniſh brown glaſs ‡.

‡ *Vauquelin, Jour. de Min.* Nº xxix. 167.

Variety 2. Indurated chlorite.

This variety is cryſtallized. Luſtre 1. Hardneſs 6. Feel meagre. Colour dark green, almoſt black. Streak mountain green.

Variety 3. Slaty chlorite.

Structure ſlaty. Fragments flatted. Internal luſtre 1 to 2. Hardneſs 5. Colour greeniſh grey, or dark green inclining to black. Streak mountain green.

A ſpecimen of the firſt variety, analyſed by Vauquelin, contained

43.3	oxide of iron,
26.0	ſilica,
15.5	alumina,
8.0	magneſia,
2.0	muriat of potaſs,
4.0	water.
98.8 §	

§ *Ann. de Chim.* xxx. 306.

A ſpecimen of the ſame variety yielded Mr Hœpner

12.92	oxide of iron,
37.50	ſilica,
4.17	alumina,
43.75	magneſia,
1.66	lime.
100.0 *	

* *Sauſſure's Voyages*, ii. 133.

A ſpecimen of the ſecond variety, analyſed by the ſame chemiſt, contained

10.15	oxide of iron,
41.15	ſilica,
6.13	alumina,
39.47	magneſia,
1.50	lime,
1.50	air and water.
99.90 †	

† *Crell's Annals*, 1790, p. 56.

On the ſuppoſition that theſe analyſes are accurate, the enormous difference between them is a demonſtration that chlorite is not a chemical combination, but a mechanical mixture.

GENUS XIV. SLAM.

78 G. XIV. SLAM. Siliceous-ſpar.

SPECIES 1. Siliceous ſpar (D).

This ſtone has been found in Tranſylvania. It is cryſtallized in 4 or 6 ſided priſms, channelled tranſverſely, and generally heaped together. Its texture is fibrous. Its luſtre ſilky, 2. Its colours white, yellow, green, light blue. According to Bindheim, it contains

61.1	ſilica,
21.7	lime,
6.6	alumina,
5.0	magneſia,
1.3	oxide of iron,
3.3	water.
99.0 *	

* *Berg.* vi. 104.

GENUS XV. SAMLI.

79 G. XV. SAMLI. Argillite. † *Kirw.* i. 234.

SPECIES 1. Argillite †.

Argillaceous ſhiſtus—Common ſlate.

This ſtone conſtitutes a part of many mountains. Its ſtructure is ſlaty. Its texture foliated. Fracture ſplintery. Fragments often tabular. Luſtre, moſt commonly ſilky, 2; ſometimes 0. Tranſparency from 0 to 1. Hardneſs from 5 to 8. Sp. gr. from 2.67 to 2.88. Does not adhere to the tongue. Gives a clear ſound when ſtruck. Often imbibes water. Streak white or grey. Colour moſt commonly grey, with a ſhade of blue, green, or black; ſometimes purpliſh, yellowiſh mountain green, brown, bluiſh black: ſometimes ſtriped or ſpotted with a darker colour than the ground.

It is compoſed, according to Kirwan, of ſilica, alumina, magneſia, lime, oxide of iron. In ſome varieties the

(D) Is this the *tremolite* of Lowitz from the lake Baikal in Siberia? If ſo, the name of the genus ought to be SLM; for he found it contain no alumina. According to his analyſis, it was compoſed of

52	ſilica,
20	lime,
12	carbonat of lime,
12	magneſia,
96	

The

Earths and Stones.

the lime is wanting. Several varieties contain a conſiderable quantity of carbonaceous matter.

G. XVI. SLACMI. Smaragdite.

GENUS XVI. SLACMI.

SPECIES 1. Smaragdite.

This ſtone was called *ſmaragdite* by Mr Sauſſure, from ſome reſemblance which it has to the emerald. Its texture is foliated. The laminæ are inflexible. Fracture even. Hardneſs 7. Colour in ſome caſes fine green, in others it has the grey colour and metallic luſtre of mica: it aſſumes all the ſhades of colour between theſe two extremes *.

According to the analyſis of Vauquelin, it is compoſed of

50.0	ſilica,
13.0	lime,
11.0	alumina,
7.5	oxide of chromum,
6.0	magneſia,
5.5	oxide of iron,
1.5	oxide of copper.
94.5 †	

* *Hauy, Jour. de Min* N° xxviii. 272.

† *Ann. de Chim.* xxx. 106.

81 G. XVII. SM. Kiffekil.

GENUS XVII. SM.

SPECIES 1. Kiffekil ‡.

Myrſen—Seafroth.

This mineral is dug up near Konie in Natolia, and is employed in forming the bowls of Turkiſh tobacco pipes. The ſale of it ſupports a large monaſtery of derviſes eſtabliſhed near the place where it is dug. It is found in a large fiſſure ſix feet wide, in grey calcareous earth. The workmen aſſert, that it grows again in the fiſſure §, and puffs itſelf up like froth (E). This mineral, when freſh dug, is of the conſiſtence of wax; it feels ſoft and greaſy; its colour is yellow; its ſp. gr. 1.600 *: when thrown on the fire it ſweats, emits a fetid vapour, becomes hard, and perfectly white.

According to the analyſis of Klaproth, it is compoſed of

50.50	ſilica,
17.25	magneſia,
25.00	water,
5.00	carbonic acid,
.50	lime.
98.25 †	

‡ *Kirwan's Min.* i. 144.

§ *Reignegg. Philoſ. Mag.* iii. 165.

* *Klaproth.*

† *Beiträge,* ii. 172.

82 Steatites.

SPECIES 2. Steatites (F).

Though this mineral was noticed by the ancients, little attention was paid to it by mineralogiſts, till Mr Pott publiſhed his experiments on it in the Berlin Memoirs for 1747.

It is uſually amorphous, but ſometimes it is cryſtallized in ſix-ſided priſms. Its texture is commonly earthy, but ſometimes foliated. Luſtre from 0 to 2. Tranſpareney from 0 to 2. Hardneſs 4 to 7. Sp. gr. from 2.61 to 2.794 ‡. Feels greaſy. Seldom adheres to the tongue. Colour uſually white or grey; often with a tint of other colours; the foliated commonly green. Does not melt *per ſe* before the blow-pipe.

‡ *Briſſon.*

Simple Stones.

Variety 1. Semi-indurated ſteatites.

Texture earthy. Fracture ſometimes coarſe ſplintery. Luſtre 0. Tranſparency 0, or ſcarce 1. Hardneſs 4 to 5. Abſorbs water. Takes a poliſh from the nail. Colour white, with a ſhade of grey, yellow, or green; ſometimes pure white; ſometimes it contains dendritical figures; and ſometimes red veins.

Variety 2. Indurated ſteatites.

Fracture fine ſplintery, often mixed with imperfectly conchoidal. External luſtre 2 to 1, internal 0. Tranſparency 2. Often has the feel of ſoap. Abſorbs water. Colour yellowiſh or greeniſh grey; often veined or ſpotted with deep yellow or red.

Variety 3. Foliated or ſtriated ſteatites.

The texture of this variaty is uſually foliated; ſometimes ſtriated. Fragments cubiform. Luſtre 3. Tranſparency 2 to 1. Hardneſs 6 to 7. Colour leek green, paſſing into mountain green or ſulphur yellow. Streak pale greeniſh grey. When heated to redneſs, it becomes grey; and at 147° Wedgewood, it forms a grey porous porcelain maſs*.

A ſpecimen of ſteatites, analyſed by Klaproth, contained

59.5	ſilica,
30.5	magneſia,
2.5	iron,
5.5	water.
98.0 †	

* *Kirwan,* i. 155.

A ſpecimen of white ſteatites, analyſed by Mr Chenevix, contained

60.00	ſilica,
28.50	magneſia,
3.00	alumina,
2.50	lime,
2.25	iron.
96.25 ‡	

† *Beiträge,* ii. 179.

‡ *Ann. de Chim.* xxviii. 200.

83 G. XVIII. MSI. Chryſolite.

GENUS XVIII. MSI.

SPECIES 1. Chryſolite (G).

Peridot of the French—*Topaz* of the ancients.

The name *chryſolite* was applied, without diſcrimination, to a great variety of ſtones, till Werner defined it accurately, and confined it to that ſtone which the French chemiſts diſtinguiſh by the appellation of *peridot*. This ſtone is the *topaz* of the ancients; their chryſolite is now called *topaz* *.

Chryſolite is found ſometimes in unequal fragments, and ſometimes cryſtallized †. The primitive form of its cryſtals is a right angled parallelopiped ‡, whoſe length, breadth, and thickneſs, are as 5, $\sqrt{8}$, $\sqrt{5}$ §.

The texture of the chryſolite is foliated. Its fracture conchoidal. Its internal luſtre from 2 to 4. Its tranſparency from 4 to 2. Cauſes double refraction. Hardneſs

* *Plinii,* lib 37. c. 8.

† Fig. 23.

‡ Fig. 24.

§ *Hauy, Jour. de Min.* N° xxviii. 281.

The carbonat of lime was only mechanically interpoſed between the fibres of the ſtone. See *Pallas, Neu. Nord. Beiträge, 6 Band,* p. 146.

(E) Hence the name *kiff-kil,* or rather *keff-kelli,* "clay froth," or "light clay."

(F) *Kirw.* I. 151.—*Pott, Mem. Berlin,* 1747, p. 57.—*Wiegleb, Jour. de Phyſ.* XXIX. 60.—*Lavoiſier, Mem. Par.* 1778, 433.

(G) *Kirw.* I. 262.—*Cartheuſer, Min.* 94.—*Dolomieu, Jour. de Min.* N° xxix. 365.—*La Metherie, Nouv. Jour. de Phyſ.* I. 397.

Earths and Stones. Hardnefs 9 to 10. Brittle. Sp. gr. from 3.265 to 3.45. Colour green. It is infufible at 150°, but lofes its tranfparency, and becomes blackifh grey *. With borax it melts without effervefcence into a tranfparent glafs of a light green colour. Infufible with microcofmic falt † and fixed alkali ‡.

* Kir. Min. i. 263.

† Vauquelin, Ann. de Chim. xxi. 97.

Variety 1. Common chryfolite.

Found in Ceylon, and South America, and in Bohemia, amidft fand and gravel §. Luftre 3 to 4. Tranfparency 4 to 3. Colour yellowifh green, fometimes verging to olive green, fometimes to pale yellow.

‡ Kirw. ibid. § Coquebert, Jour. de Min. N° xxii. 20.

Variety 2. Olive chryfolite—*Olivine* *.

* Kirwan's Min. i. 263—Le Lievre, Jour. de Phyf. xxx. 397.

Found commonly among traps and bafalts; fometimes in fmall grains, fometimes in pretty large pieces; but it has not been obferved in cryftals. Luftre 2 to 3. Tranfparency 3 to 2. Colour olive green.

The firft variety, according to the analyfis of Klaproth, is compofed of 41.5 magnefia,
38.5 filica,
19.0 oxide of iron.

99.0 †

† Klaprotb's Beiträge, i. 103.

According to that of Vauquelin, it is compofed of
51.5 magnefia,
38.0 filica,
9.5 oxide of iron.

99.0 ‡

‡ Ann de Chim. ibid.

The fecond variety, according to the analyfis of Klaproth, is compofed of 37.58 magnefia,
50.00 filica,
11.75 oxide of iron,
.21 lime.

99.54 §

§ Beiträge, i. 112.

Species 2. Jade (H).

84 Jade.

This ftone was formerly called *lapis naphriticus*, and was much celebrated for its medical virtues. It is found in Egypt, China, America, and in the Siberian and Hungarian mountains. It is fometimes adhering to rocks, and fometimes in detached round pieces.

Its furface is fmooth. Its fracture fplintery. External luftre 0, or fcarce 1; internal waxy, 1. Tranfparency from 2 to 1. Hardnefs 10. Not brittle. Sp. gr. from 2.95 to 2.9829; or, according to Sauffure, to 3 389. Feels greafy. Looks as if it had imbibed oil. Colour dark leek green, or verging towards blue; in fome prominences inclining to greenifh or bluifh white. When heated it becomes more tranfparent and brittle, but is infufible *per fe*. According to Hoepfner, it is compofed of
47 filica,
38 carbonat of magnefia,
9 iron,
4 alumina,
2 carbonat of lime.

100

This is the ftone in which the inhabitants of New Zealand make into hatchets and other cutting inftruments.

Genus XIX. sml.

species 1. Afbeftus (I).

85 G. XIX. sml. Afbeftus.

This mineral was well known to the ancients. They even made a kind of cloth from one of the varieties, which was famous among them for its incombuftibility. It is found abundantly in moft mountainous countries, and no where more abundantly than in Scotland.

It is commonly amorphous. Its texture is fibrous. Its fragments often long fplintery. Luftre from 0 to 2; fometims 3, and then it is metallic. Tranfparency from 0 to 2. Hardnefs from 3 to 7. Sp. gr. from 2.7 to 0.6806. Abforbs water. Colour ufually white or green. Fufible *per fe* by the blow-pipe.

Variety 1. Common afbeftus.

Luftre 2 to 1. Tranfparency 1. Hardnefs 6 to 7. Sp. gr. 2.577 to 2.7. Feels fomewhat greafy. Colour leek green; fometimes olive or mountain green; fometimes greenifh or yellowifh grey. Streak grey. Powder grey.

Variety 2. Flexible afbeftus.

Amiantus.

Compofed of a bundle of threads flightly cohering. Fibres flexible. Luftre 1 to 2, fometimes 3. Tranfparency 1 to 2, fometimes 0. Hardnefs 3 to 4. Sp. gr. before it abforbs water, from 0.9088 to 2.3134; after abforbing water, from 1.5662 to 2.3803 *. Feels greafy. Colour greyifh or greenifh white; fometimes yellowifh or filvery white, olive or mountain green, pale flefh red, and mountain yellow.

* Briffon.

Variety 3. Elaftic afbeftus.

Mountain cork.

This variety has a ftrong refemblance to common cork. Its fibres are interwoven. Luftre commonly 0. Opaque. Hardnefs 4. Sp. gr. before abforbing water, from 0.6806 to 0.9933; after abforbing water, from 1.2492 to 1.3492. Feels meagre. Yields to the fingers like cork, and is fomewhat elaftic. Colour white; fometimes with a fhade of red or yellow; fometimes yellow or brown.

A fpecimen of the firft variety from Dalecarlia, analyfed by Bergman, contained
63.9 filica,
16.0 carbonat of lime,
12.8 carbonat of magnefia,
6.0 oxide of iron,
1.1 alumina.

99.8 *

* Opufc. iv. 170.

A fpecimen of the fecond variety yielded to the fame chemift
64.0 filica,
17.2 carbonat of magnefia,
13.9 carbonat of lime,
2.7 alumina,
2.2 oxide of iron.

100.0 ‡

‡ Ibid. p. 163.

A fpecimen of the third variety contained, according to the fame analyfis, 56.2 filica,
26.1 carbonat of magnefia,
12.7 carbonat of lime,
3.0 iron,
2.0 alumina.

100.0 §

§ Ibid. p. 170.

Twelve

(H) *Kirw.* I. 171.—*Bartolin, De Lapide Nephritico.—Lehman, Nov. Comm. Petropol.* X. 381.—*Hoepfner, Hift. Nat. de la Suiffe*, I. 251.

(I) *Kirw.* I. 159.—*Bergman*, IV. 160—*Plot, Phil. Tranf.* XV. 1051.—*Nebel, Jour. de Phyf.* II. 62.—*Ibid.* III. 367.

Earths and Stones.

Twelve different ſpecimens of aſbeſtus, analyſed by Bergman, yielded the ſame ingredients, differing a little in their proportions *.

* *Opuſc.* iv. 175.

85 Aſbeſtinite.

SPECIES 2. Aſbeſtinite (K).

This ſtone is amorphous. Texture foliated or broad ſtriated. Luſtre ſilky, 3. Tranſparency 1 to 2. Hardneſs 5 to 6. Sp. gr. from 2.806 to 2.880. Colour white with ſhades of red, yellow, green or blue. At 150° Wedgewood it melts into a green glaſs.

87 G. XX. 1. SILM. Pyroxen.

GENUS XX. 1. SILM.

SPECIES 1. Pyroxen.

This ſtone is found abundantly in lava and other volcanic productions (L). It is always cryſtallized. The primitive form of its cryſtals is an oblique angled priſm, whoſe baſes are rhombs with angles of 92° 18′, and 37° 42′ †. It generally cryſtallizes in eight-ſided priſms, terminated by dihedral ſummits ‡. Its texture is foliated. Hardneſs 9. Colour black; ſometimes green. Powder greeniſh grey §. Commonly attracted by the magnet *. Scarcely fuſible by the blow pipe †. With borax it melts into a yellowiſh glaſs, which appears red while it is hot ‡.

† *Hauy, Jour. de Min.* N° xxviii. 269.
‡ *De Liſle,* ii. 398.
§ *Vauquelin*
* *Ferber.*
† *Le Lievre.*
‡ *Vauquelin.*

According to the analyſis of Vauquelin, it is compoſed of

52.00	ſilica,
14.66	oxide of iron,
13.20	lime,
10.00	magneſia,
3.33	alumina,
2.00	oxide of mangaueſe.
95.19 §	

§ *Jour de Min.* N° xxxix. 171.

88 Aſbeſtoid.

SPECIES 2. Aſbeſtoid *.

This ſtone has obtained its name from its ſimilarity to common aſbeſtus. It is amorphous. Its texture is foliated or ſtriated. Its luſtre common or glaſſy, from 2 to 3. Tranſparency from 0 to 1. Hardneſs 6 to 7. Sp. gr. from 3 to 3.31. Colour olive or leek green; when decompoſing, brown. Before the blowpipe it melts *per ſe* into a brown globule. With borax it forms a violet coloured globule verging towards hyacinth *. According to the analyſis of Mr Macquart, it is compoſed of

* *Kirwan,* i. 166.
* *Macquart, Ann. de Chim.* xxii. 83.

46	ſilica,
20	oxide of iron,
11	lime,
10	oxide of mangaueſe,
8	magneſia.
95 †	

† *Ibid.*

There is a variety of this ſpecies which Kirwan calls metalliform aſbeſtoid. Its luſtre is ſemimetallic, 3. Opaque. Hardneſs 8 to 9. Sp. gr. 3.356. Colour grey, ſometimes inclining to red ‡.

‡ *Kirwan's Min.* i. 167.

Simple Stones.

89 G. XX. 2. SMIL. Shorlaceous actinolite.

GENUS XX. 2. SMIL.

SPECIES 3. Shorlaceous actinolite (M).

This ſtone cryſtallizes in four or ſix ſided priſms, thicker at one end than the other; hence it has been called by the Germans *ſtrahlſtein*, "arrow-ſtone." The cryſtals ſometimes adhere longitudinally. Fracture hackly. External luſtre glaſſy, 3 to 4; internal, 1 to 2. Tranſparency from 2 to 3; ſometimes 1. Hardneſs from 7 to 10. Sp. gr. 3.023 to 3.45. Colour leek or dark green.

This ſtone is often the matrix of iron, copper, and tin ores.

90 Lamellar actinolite.

SPECIES 5. Lamellar actinolite.

This ſtone reſembles hornblende. It is amorphous. Texture foliated. Luſtre various in different places. Tranſparency 0, or ſcarce 1. Sp. gr. 2.916. Colour dark yellowiſh or greeniſh grey.

91 Glaſſy actinolite.

SPECIES 6. Glaſſy actinolite.

This ſtone is found amorphous, compoſed of fibres adhering longitudinally, or in ſlender four or ſix ſided priſms. Texture fibrous. Fragments long ſplintery, ſo ſharp that they can ſcarcely be handled without injury. External luſtre glaſſy or ſilky, 3 to 4; internal 0. Tranſparency 2. Exceedingly brittle. Sp. gr. 2.95 to 2.493. Colour leek green; ſometimes verging towards greeniſh or ſilver white; ſometimes ſtained with yellowiſh or browniſh red. According to Bergman it is compoſed of

72.0	ſilica,
12.7	carbonat of magneſia,
6.0	carbonat of lime,
7.0	oxide of iron,
2.0	alumina.
99.7 §	

§ *Opuſc.* iv. 171.

92 G. XXI. SL. Shiſtoſe hornſtone.

GENUS XXI. SL.

SPECIES 1. Shiſtoſe hornſtone *.

* *Kirwan,* i. 305.

The ſtructure of this ſtone is ſlaty. Luſtre from 0 to 1. Commonly opaque. Hardneſs 9 to 10. Sp. gr. from 2.596 to 2.641. Colour dark bluiſh or blackiſh grey. Infuſible *per ſe*.

Variety 1. Siliceous ſhiſtus.

Commonly interſected by reddiſh veins of iron ſtone. Fracture ſplintery. Luſtre 0. Tranſparency from 0 to 1.

Variety 2. Baſanite or Lydian ſtone.

Commonly interſected by veins of quartz. Fracture even; ſometimes inclining to conchoidal. Luſtre ſcarce 1. Hardneſs 10. Sp. gr. 2.596. Powder black. Colour greyiſh black.

This, or a ſtone ſimilar to it, was uſed by the ancients as a touchſtone. They drew the metal to be examined along the ſtone, and judged of its purity by the

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(K) *Kirw. Min.* I. 165. Is this the *tremolite* of Werner? It certainly is not the *tremolite* of the French mineralogiſts.

(L) Hence the name *pyroxen* given it by Hauy; from πυρ *fire*, and ξενος, *a ſtranger*. It means, as he himſelf explains it, *a ſtranger in the regions of fire*. By this he means to indicate, that pyroxen, though preſent in lava, is not a volcanic production.

(M) In this and the following ſpecies we have followed Mr. Kirwan's new arrangement exactly, without even venturing to give the ſynonimes of other authors. The deſcriptions which have been given are ſo many and incomplete, and the minerals themſelves are ſtill ſo imperfectly known, and have got ſo many names, that no part of mineralogy is in a ſtate of greater confuſion.

Earths and Stones.

the colour of the metallic streak. On this account they called it *βασανος, the trier*. They called it also *Lydian stone*, because, as Theophrastus informs us, it was found most abundantly in the river Tmolus in Lydia *. A specimen of the first variety, analysed by Wiegleb, contained

75.0	silica,
10.0	lime,
4.6	magnesia,
3.5	iron,
5.2	carbon.
98.3	

* Hill's Theophrastus, περι λιθων, p. 190.

This species is rather a mechanical mixture than a chemical combination.

93 G. XXII. zs. Zircon.

Genus XXII. zs.

SPECIES I. Zircon †.

Jargon—Hyacinth.

† Kirwan, i. 257. and 333.

This stone is brought from Ceylon, and found also in France, Spain, and other parts of Europe. It is commonly crystallized. The primitive form of its crystals is an octahedron ‡, composed of two four-sided pyramids applied base to base, whose sides are isosceles triangles (N). The inclination of the sides of the same pyramid to each other is 124° 12′; the inclination of the sides of one pyramid to those of another 82° 50′. The solid angle at the apex is 73° 44′ §. The varieties of the crystalline forms of zircon amount to seven. In some cases there is a four-sided prism interposed between the pyramids of the primitive form; sometimes all the angles of this prism are wanting, and two small triangular faces in place of each; sometimes the crystals are dodecahedrons, composed of a flat four-sided prism with hexagonal faces, terminated by four-sided summits with rhomboidal faces ‖; sometimes the edges of this prism, sometimes the edges where the prism and summit join, and sometimes both together, are wanting, and we find small faces in their place. For an accurate description and figure of these varieties, we refer to *Mr Hauy* ¶.

‡ Fig. 25.

§ Hauy, Jour. de Min. N° xxvi. 91.

‖ Fig. 26.

¶ Ibid.

The texture of the zircon is foliated. Internal lustre 3. Transparency from 4 to 2. Causes a very great double refraction. Hardness from 10 to 16. Sp. gr. from 4.2 to 4.165 *. Colour commonly reddish or yellowish; sometimes it is limpid.

* Ibid.

Before the blow-pipe it loses its colour, but not its transparency. With borax it melts into a transparent glass. Infusible with fixed alkali and microcosmic salt.

1. The variety formerly called *hyacinth* is of a yellowish red colour, mixed with brown. Its surface is smooth. Its lustre 3. Its transparency 3 to 4.

2 The variety formerly called *jargon of Ceylon*, is either grey, greenish, yellowish brown, reddish brown, or violet. It has little external lustre. Is sometimes nearly opaque.

The first variety, according to the analysis of Vauquelin, is composed of

64.5	zirconia,
32.0	silica,
2.0	oxide of iron.
98.5 †	

† Ibid. p. 106.

A specimen analysed by Klaproth contained

70.0	zirconia,
25.0	silica,
0.5	oxide of iron.
95.5 *	

* Beiträge, i. 231.

The second variety, according to Klaproth, who discovered the component parts of both these stones, contains

60.0	zirconia,
31.5	silica,
0.5	nickel and iron.
100.0 ‡	

‡ Ibid. i. 219.

Saline Stones.

Order II. SALINE STONES.

94 Genera.

Under this order we comprehend all the minerals which consist of an earthy basis combined with an acid. They naturally divide themselves into five genera. We shall describe them in the following order.

I. CALCAREOUS SALTS.
- Carbonat of lime,
- Sulphat of lime,
- Phosphat of lime,
- Fluat of lime,
- Borat of lime.

II. BARYTIC SALTS.
- Carbonat of barytes,
- Sulphat of barytes.

III. STRONTITIC SALTS.
- Carbonat of strontites,
- Sulphat of strontites.

IV. MAGNESIAN SALTS.
- Sulphat of magnesia.

V. ALUMINOUS SALTS.
- Alum.

95 G. I. Calcareous salts.

Genus I. CALCAREOUS SALTS.

This genus comprehends all the combinations of lime and acids which form a part of the mineral kingdom.

96 Carbonat of lime.

SPECIES I. Carbonat of lime.

No other mineral can be compared with carbonat of lime in the abundance with which it is scattered over the earth. Many mountains consist of it entirely, and hardly a country is to be found on the face of the globe where, under the names of limestone, chalk, marble, spar, it does not constitute a greater or smaller part of the mineral riches.

It is often amorphous, often stalactitical, and often crystallized. The primitive form of its crystals is a parallelopiped, whose sides are rhombs, with angles of 77° 30′ and 102° 30′ ‡. Its integrant molecules have the same form. The varieties of its crystals amount to more than 40; for a description and figure of which we refer to *Romé de Lisle* * and *Hauy* (O).

‡ Fig. 28.

* Crystal. i. 497.

When crystallized, its texture is foliated; when amorphous, its structure is sometimes foliated, sometimes striated, sometimes granular, and sometimes earthy. Its lustre

(N) Let ABC (fig. 27.) be one of the sides. Draw the perpendicular BD; then AB = 5, BD = 4, AD = 3.

(O) *Essai d'une Theorie*, &c. p. 75.—*Jour. de Phys.* 1793, August, p. 114.—*Jour. d'Hist. Nat.* 1792, February, p. 148.—*Ann. de Chim.* XVII. 249. &c.—*Jour. de Min.* N° XXVIII. 304.

luftre varies from o to 3. Tranfparency from o to 4. It caufes double refraction; and it is the only mineral which caufes double refraction through two parallel faces of the cryftal. Hardnefs from 3 to 9. Sp. gr. from 2.315 to 2.78. Colour, when pure, white. Effervefces violently with muriatic acid, and diffolves completely, or leaves but a fmall refiduum. The folution is colourlefs.

This fpecies occurs in a great variety of forms; and therefore has been fubdivided into numerous varieties. All thefe may be conveniently arranged under two general divifions.

I. Soft carbonat of lime.

Variety 1. Agaric mineral.

Mountain milk, or *mountain meal* of the Germans.

This variety is found in the clefts of rocks, or the bottom of lakes. It is nearly in the ftate of powder; of a white colour, fometimes with a fhade of yellow; and fo light that it almoft floats on water.

Variety 2. Chalk.

The colour of chalk is white, fometimes with a fhade of yellow. Luftre o. Opaque. Hardnefs 3 to 4. Sp. gr. from 2.315 to 2657. Texture earthy. Adheres flightly to the tongue. Feels dry. Stains the fingers, and marks. Falls to powder in water. It generally contains about $\frac{2}{100}$ of alumina, and $\frac{3}{100}$ of water; the reft is carbonat of lime.

Variety 3. Arenaceous limeftone.

Colour yellowifh white. Luftre 1. Tranfparency 1. So brittle that fmall pieces crumble to powder between the fingers. Sp. gr. 2.742. Phofphorefces in the dark when fcraped with a knife, but not when heated. It confifts almoft entirely of pure carbonat of lime.

Variety 4. Teftaceous tufa.

The colour of this variety is yellowifh or greyifh white. It is exceedingly porous and brittle; and is either compofed of broken fhells, or refembles mortar containing fhells; or it confifts of fiftulous concretions varioufly ramified, and refembling mofs.

II. Indurated carbonat of lime.

Variety 1. Compact limeftone.

The texture of this variety is compact. It has little luftre; and is moft commonly opaque. Hardnefs 5 to 8. Sp. gr. 1.3864 to 2.72. Colour grey, with various fhades of other colours. It moft commonly contains about $\frac{1}{10}$th of alumina, oxide of iron, &c.; the reft is carbonat of lime. This variety is ufually burnt as lime.

Variety 2. Granularly foliated limeftone.

Structure fometimes flaty. Texture foliated and granular. Luftre 2 to 1. Tranfparency 2 to 1. Hardnefs 7 to 8 Sp. gr. 2.71 to 2.8376. Colour white, of various fhades from other colours.

Variety 3. Sparry limeftone.

Structure fparry. Texture foliated. Fragments rhomboidal. Luftre 2 to 3. Tranfparency from 2 to 4; fometimes 1. Hardnefs 5 to 6. Sp. gr. from 2.693 to 2.718. Colour white; often with various fhades of other colours. To this variety belong all the cryftals of carbonat of lime.

Variety 4. Striated limeftone.

Texture ftriated or fibrous. Luftre 1 to o. Tranfparency 2 to 1. Hardnefs 5 to 7. Sp. gr. commonly from 2.6 to 2.77. Colours various.

Variety 5. Swine ftone.

Texture often earthy. Fracture often fplintery. Luftre 1 to o. Tranfparency o to 1. Hardnefs 6 to 7. Sp. gr. 2.701 to 2.7121. Colour dark grey, of various fhades. When fcraped or pounded it emits an urinous or garlic fmell.

Variety 6. Oviform.

This variety confifts of a number of fmall round bodies, clofely compacted together. Luftre o. Tranfparency o or 1. Hardnefs 6 to 7.

SPECIES 2. Sulphat of lime. 97 Sulphat of lime.

Gypfum — Selenite.

This mineral is found abundantly in Germany, France, England, Italy, &c.

It is found fometimes in amorphous maffes, fometimes in powder, and fometimes cryftallized. The primitive form of its cryftals, according to Romé de Lifle, is a decahedron *, which may be conceived as two four-fided pyramids applied bafe to bafe, and which, inftead of terminating in pointed fummits, are truncated near their bafes; fo that the fides of the pyramids are trapeziums, and they terminate each in a rhomb. Thefe rhombs are the largeft faces of the cryftal. The angles of the rhombs are 52° and 158°. The inclination of two oppofite faces of one pyramid to the two fimilar faces of the other pyramid is 145°, that of the other faces 110 †. Sometimes fome of the faces are elongated; fometimes it cryftallizes in fix-fided prifms, terminated by three or four-fided fummits, or by an indeterminate number of curvilinear faces. For a defcription and figure of thefe varieties, we refer to *Romé de Lifle* ‡.

* Fig. 29.

† *Cryftal.* i. 144.

‡ *Ibid.*

The texture of fulphat of lime is moft commonly foliated. Luftre from o to 4. Tranfparency from o to 4. It caufes double refraction. Its hardnefs does not exceed 4. Its fp. gr. from 1.872 to 2.311. Colour commonly white or grey.

Before the blow-pipe, it melts into a white enamel, provided the blue flame be made to play upon the edges of its laminæ. When the flame is directed againft its faces, the mineral falls into powder §.

It does not effervefce with muriatic acid, except it be impure; and it does not diffolve in it.

§ *Le Lievre, Jour. de Min.* N° xxviii. 315.

The following varieties of this mineral are deferving of attention.

Variety 1. Broad foliated fulphat.

Texture broad foliated. Luftre glaffy, from 4 to 2. Tranfparency from 4 to 3. Hardnefs 4. Sp. gr. 2.311. Colour grey, often with a fhade of yellow.

Variety 2. Grano-foliated fulphat.

Texture foliated, and at the fame time granular; fo that it eafily crumbles into powder. Luftre 2 to 3. Tranfparency 2 to 3. Hardnefs 4 to 3. Sp. gr. from 2.274 to 2.310. Feels foft. Colour white or grey, often with a tinge of yellow, blue, or green; fometimes flefh red, brown, or olive green.

Variety 3. Fibrous fulphat.

Texture fibrous. Fragments long fplintery. Luftre 2 to 3. Tranfparency 2 to 1; fometimes 3. Hardnefs 4. Brittle. Sp. gr. 2.300. Colour white, often with a fhade of grey, yellow, or red; fometimes flefh red, and fometimes honey yellow; fometimes feveral of thefe colours meet in ftripes.

Variety 4. Compact fulphur.

Texture compact. Luftre 1 or o. Tranfparency 2 to 1, Earths and Stones. 1, sometimes 0. Hardness 4. Sp. gr. from 1.872 to 2.288. Feels dry, but not harsh. Colour white, with a shade of grey, yellow, blue, or green; sometimes yellow; sometimes red; sometimes spotted, striped, or veined.

Variety 5. Farinaceous sulphat.

Of the consistence of meal. Lustre 0. Opaque. Scarcely sinks in water. Is not gritty between the teeth. Feels dry and meagre. Colour white. When heated below redness, it becomes of a dazzling white.

98 Phosphat of lime.

SPECIES 3. Phosphat of lime.

Apatite—Phosphorite—Chrysolite—of the French.

This substance is found in Spain, where it forms whole mountains, and in different parts of Germany. It is sometimes amorphous, and sometimes crystallized. The primitive form of its crystals is a regular six-sided prism *. Its integrant molecule is a regular triangular prism, whose height is to a side of its base as 1 to $\sqrt{2}$ †. Sometimes the edges of the primitive hexagonal prism are wanting, and small faces in their place; sometimes there are small faces instead of the edges which terminate the prism; sometimes these two varieties are united; sometimes the terminating edges and the angles of the prism are replaced by small faces ‡; and sometimes the prism is terminated by four sided pyramids §.

* Fig. 30.

† *Hauy, Jour. de Min.* N° xxviii. p. 310.

‡ Fig. 31.

§ *Hauy, ibid.*

Its texture is foliated. Its fracture uneven, tending to conchoidal. External lustre from 2 to 3, internal 3 to 2. Transparency from 4 to 2. Causes single refraction. Hardness 6 to 7. Brittle. Sp. gr. from 2.8249 to 3.218. Colour commonly green or grey; sometimes brown, red, blue, and even purple.

It is infusible by the blow-pipe. When its powder is thrown upon burning coals, it emits a yellowish green phosphorescent light. It is soluble in muriatic acid without effervescence or decomposition, and the solution often bomes gelatinous.

99 Fluat of lime.

SPECIES 4. Fluat of lime.

Fluor.

This mineral is found abundantly in different countries, particularly in Derbyshire. It is both amorphous and crystallized.

The primitive form of its crystals is the regular octohedron; that of its integrant molecules the regular tetrahedron ‖. The varieties of its crystals hitherto observed amount to 7. These are the primitive octohedron; the cube: the rhomboidal dodecahedron; the cubo octohedron ¶, which has both the faces of the cube and of the octohedron; the octohedron wanting the edges; the cube wanting the edges, and either one face *, or two faces in place of each. For a description and figure of these we refer to *Mr Hauy* †.

‖ *Hauy, ibid.* p. 325.

¶ Fig. 32.

* Fig. 33.

† *Ibid.*

The texture of fluat of lime is foliated. Lustre from 2 to 3, sometimes 0. Transparency from 2 to 4, sometimes 1. Causes single refraction. Hardness 8. Very brittle. Sp. gr. from 3.0943 to 3.1911. Colours numerous, red, violet, green, red, yellow, blackish purple. Its powder thrown upon hot coals emits a bluish or greenish light. Two pieces of it rubbed in the dark phosphoresce. It decrepitates when heated. Before the blow-pipe it melts into a transparent glass. §

§ *Ibid.*

It admits of a polish, and is often formed into vases and other ornaments.

100 Borat of lime.

SPECIES 5. Borat of lime.

Boracite.

This mineral has been found at Kalkberg near Luneburg, seated in a bed of sulphat of lime. It is crystallized. The primitive form of its crystals is the cube *. In general, all the edges and angles of the cube are truncated; sometimes, however, only the alternate angles are truncated †. The size of the crystals does not exceed half an inch.

Saline Stones.

* *Hauy, Jour. de Min.* N° xxvii. p. 325.

† *Hauy*, and *Westrum.*

The texture of this mineral is compact. Its fracture is flat conchoidal. External lustre 3; internal, greasy, 2. Transparency from 2 to 3. Hardness 9 to 10. Sp. gr. 2.566. Colour greyish white, sometimes passing into greenish white or purplish.

When heated it becomes electric; and the angles of the cube are alternately positive and negative ‡.

‡ *Hauy, ibid.* and *Ann. de Chim.* ix. 59.

Before the blow-pipe it froths, emits a greenish light, and is converted into a yellowish enamel, garnished with small points, which, if the heat be continued, dart out in sparks §.

§ *Le Lievre, Jour. de Min. ibid.*

According to Westrum, who discovered its component parts, it contains

68	boracic acid,
13.5	magnesia,
11	lime,
1	alumina,
2	silica,
1	iron.
96 ¶	

¶ *Ann. de Chim.* ii. 116.

101 Nitrat of lime.

SPECIES 6. Nitrat of lime.

Found abundantly mixed with native nitre. For a description see the article CHEMISTRY in this *Supplement*, n° 672.

102 G. II. Barytic salts.

GENUS II. BARYTIC SALTS.

This genus comprehends the combinations of barytes with acids.

103 Carbonat of barytes.

SPECIES 1. Carbonat of barytes.

Witherite.

This mineral was discovered by Dr Withering; hence Werner has given it the name of *witherite*. It is found both amorphous and crystallized. The crystals are octohedrons or dodecahedrons, consisting of four or six sided pyramids applied base to base; sometimes the six-sided pyramids are separated by a prism; sometimes several of these prisms are joined together in the form of a star.

Its texture is fibrous. Its fracture conchoidal. Its fragments long splintery. Lustre 2. Transparency 2 to 3. Hardness 5 to 6. Brittle. Sp. gr. 4.3 to 4.338. Colour greenish white. When heated it becomes opaque. Its powder phosphoresces when thrown on burning coals *.

* *Hauy,*

It is soluble with effervescence in muriatic acid. The solution is colourless.

According to Pelletier it contains

62	barytes,
22	carbonic acid,
16	water.
100 †	

† *Jour. de Min.* N° xxi. p. 46.

104 Sulphat of barytes.

SPECIES 2. Sulphat of barytes.

Borosclenite.

This mineral is found abundantly in many countries, particularly in Britain. It is sometimes in powder, often in amorphous masses, and often crystallized. The primitive form of its crystals is a rectangular prism, whose

Earths and Stones.

whofe bafes are rhombs, with angles of 101° 30′ and 78° 30′ *. The varieties of its cryftals are very numerous. For a defcription and figure of them we refer to *Romé de Lifle* † and *Hauy* ‡. The moft common varieties are the octohedron with cuneiform fummits, the fix or four fided prifm, the hexangular table with bevelled edges. Sometimes thefe cryftals are needle form.

* *Hauy, Effai d'une Theorie*, &c. p. 119.
† *Cryftal*. i. 588.
‡ *Ibid*. and *Ann. de Chim*. xii. 3.

Its texture is commonly foliated. Luftre from 0 to 2. Tranfparency from 2 to 0; in fome cafes 3 or 4. Hardnefs from 5 to 6. Sp. gr. from 4.4 to 4.44. Colour commonly white, with a fhade of yellow, red, blue, or brown.

When heated it decrepitates. It is fufible *per fe* by the blue flame of the blow-pipe, and is converted into fulphurat of barytes. Soluble in no acid except the fulphuric; and precipitated from it by water.

Variety 1. Foliated fulphat.

Luftre 3 to 3. Tranfparency from 4 to 2, fometimes 1. Colours white, reddifh, bluifh, yellowifh, blackifh, greenifh. Mr Werner fubdivides this variety into three, according to the nature of the texture. Thefe three fubdivifions are *granularly foliated*, *ftraight foliated*, *curve foliated*.

Variety 2. Fibrous fulphat.

Texture fibrous; fibres converging to a common centre. Luftre filky or waxy, 2. Tranfparency 2 to 1. Hardnefs 5. Colours yellowifh, bluifh, reddifh.

Variety 3. Compact fulphat.

Texture compact. Luftre 0 to 1. Tranfparency 1 to 0. Feels meagre. Almoft conftantly impure. Colours light yellow, red, or blue.

Variety 4. Earthy fulphat.

In the form of coarfe dufty particles, flightly cohering. Colour reddifh or yellowifh white.

Genus III. Strontitic Salts.

105 G. III. Strontitic falts.

This genus comprehends all the combinations of ftrontites and acids which form a part of the mineral kingdom.

Species 1. Carbonat of ftrontites

106 Carbonat of ftrontites.

This mineral was firft difcovered in the lead mine of Srontion in Argylefhire; and fince that time it is faid to have been difcovered, though not in great abundance, in other countries. It is found amorphous, and alfo cryftallized in needles, which, according to Hauy, are regular fix-fided prifms.

Its texture is fibrous; the fibres converge. Fracture uneven. Luftre 2. Tranfparency 2. Hardnefs 5. Sp. gr. from 3.4 to 3.66. Colour light green. Does not decrepitate when heated. Before the blow-pipe becomes opaque and white, but does not melt. With borax it effervefces, and melts into a tranfparent colourlefs glafs. Effervefces with muriatic acid, and is totally diffolved. The folution tinges flame purple.

Species 2. Sulphat of ftrontites.

Celeftine.

107 Sulphat of ftrontites.

This mineral has been found in Pennfylvania, in Germany, in France, in Sicily, and Britain. It was firft difcovered near Briftol by Mr Clayfield. There it is found in fuch abundance, that it has been employed in mending the roads.

It occurs both amorphous and cryftallized. The cryftals are moft commonly bevelled tables, fometimes rhomboidal cubes. Its texture is foliated. More or lefs tranfparent. Hardnefs 5. Sp. gr. from 3.51 to 3.96. Colour moft commonly a fine fky blue; fometimes reddifh; fometimes white, or nearly colourlefs §.

Aggregates.

§ *Clayfield, Nicholfon's Jour*. iii. 36.

Klaproth found a fpecimen of this mineral from Pennfylvania compofed of 58 ftrontites,
42 fulphuric acid.

100 ‖.

‖ *Beitrage*, ii. 97.

According to the analyfis of Mr Clayfield, the fulphat ftrontites found near Briftol is compofed of
58.25 ftrontites,
41.75 fulphuric acid of 2.24, and a little iron ¶.

100.00

¶ *Ibid. Nicholfon's Journal*.

According to the analyfis of Vauquelin, the fulphat of ftrontites found at Bouvron in France, which was contaminated with .1 of carbonat of lime, is compofed of
54 ftrontites,
45 fulphuric acid.

99 *

* *Jour. de Min*. N° xxxvii. 6.

Genus IV. Magnesian Salts.

108 G. IV. Magnefian Salts.

This genus comprehends the combinations of magnefia and acids which occur in the mineral kingdom. Only two fpecies have hitherto been found; namely,

Species 1. Sulphat of magnefia.

109 Sulphat of magnefia.

It is found in Spain, Bohemia, Britain, &c.; and enters into the compofition of many mineral waters.

For a defcription of it, we refer to Chemistry, n° 633. in this *Suppl*.

Species 2. Nitrat of magnefia.

110 Nitrat of magnefia.

Found fometimes affociated with nitre. For a defcription fee Chemistry, n° 674,

Genus V. Aluminous Salts.

111 G. V. Aluminous falts.

This genus comprehends thofe combinations of alumina and acids which occur in the mineral kingdom.

Species 1. Alum.

112 Alum.

This falt is found in cryftals, in foft maffes, in flakes, and invifibly mixed with the foil. For a defcription, we refer to Chemistry, n° 636.

Order III. AGGREGATES.

This order comprehends all mechanical mixtures of earths and ftones found in the mineral kingdom. Thefe are exceedingly numerous: the mountains and hills, the mould on which vegetables grow, and indeed the greater part of the globe, may be confidered as compofed of them. A complete defcription of aggregates belongs rather to geology than mineralogy. It would be improper, therefore, to treat of them fully here. But they cannot be altogether omitted; becaufe aggregates are the firft fubftances which prefent themfelves to the view of the practical mineralogift, and becaufe, without being acquainted with the names and component parts of many of them, the moft valuable mineralogical works could not be underftood.

113 Divifion of aggregates.

Aggregates may be comprehended under four divifions: 1. Mixtures of earths; 2. Amorphous fragments of ftones agglutinated together; 3. Cryftallized ftones, either agglutinated together or with amorphous ftones; 4. Aggregates formed by fire. It will be exceedingly convenient

Earths and Stones. convenient to treat each of these separately. We shall therefore divide this order into four sections.

Sect. I. *Aggregates of Earths.*

The most common earthy aggregates may be comprehended under the following genera:

1. Clay,
2. Colorific earths,
3. Marl,
4. Mould.

114 Clay.

Genus I. Clay.

Clay is a mixture of alumina and silica in various proportions. The alumina is in a state of an impalpable powder; but the silica is almost always in small stones, large enough to be distinguished by the eye. Clay, therefore, exhibits the character of alumina, and not of silica, even when this last ingredient predominates. The particles of silica are already combined with each other; and they have so strong an affinity for each other that few bodies can separate them; whereas the alumina, not being combined, readily displays the characters which distinguish it from other bodies. Besides alumina and silica, clay often contains carbonat of lime, of magnesia, barytes, oxide of iron, &c. And as clay is merely a mechanical mixture, the proportion of its ingredients is exceedingly various.

Clay has been divided into the following species:

115 Porcelain clay.

Species 1. Porcelain clay.

Its texture is earthy. Its lustre 0. Opaque. Hardness 4. Sp. gr. from 2.23 to 2.4. Colour white, sometimes with a shade of yellow or red. Adheres slightly to the tongue. Feels soft. Falls to powder in water.

A specimen, analysed by Hassenfratz, contained

62	silica,
19	alumina,
12	magnesia,
7	sulphat of barytes.
100 *	

* Ann. de Chim. xiv. 144.

A specimen, analysed by Mr Wedgewood, contained

60	alumina,
20	silica,
12	air of water.
92	

116 Common clay.

Species 2. Common clay.

Its texture is earthy. Lustre 0. Opaque. Hardness 3 to 6. Sp. gr. 1.8 to 2.68. Adheres slightly to the tongue. Often feels greasy. Falls to powder in water. Colour, when pure, white; often tinged blue or yellow.

Variety 1. Potter's clay.

Hardness 3 to 4. Sp. gr. 1.8 to 2. Stains the fingers slightly. Acquires some polish by friction. Colour white; often with a tinge of yellow or blue; sometimes brownish, greenish, reddish. Totally diffusible in water; and, when duly moistened, very ductile.

Variety 2. Indurated clay.

Hardness 5 to 6. Does not diffuse itself in water, but falls to powder. Discovers but little ductility. Colours grey, yellowish, bluish, greenish, reddish, brownish.

Aggregates

Variety 3. Shistose clay.

Structure slaty. Sp. gr. from 2.6 to 2.68. Feels smooth. Streak white or grey. Colour commonly bluish, or yellowish grey; sometimes blackish, reddish, greenish. Found in strata, usually in coal mines.

This variety is sometimes impregnated with bitumen. It is then called bituminous *shale*.

117 Lithomarga.

Species 3. Lithomarga.

Texture earthy. Fracture conchoidal. Lustre from 0 to 2. Opaque. Hardness 3 to 7. Sp. gr. when pretty hard, 2.815. Surface smooth, and feels soapy, Adheres strongly to the tongue. Falls to pieces, and then to powder, in water; but does not diffuse itself through that liquid. Fusible *per se* into a frothy mass.

Variety 1. Friable lithomarga.

Formed of scaly particles slightly cohering. Lustre 1 to 0. Hardness 3 to 4. Exceedingly light. Feels very smooth, and assumes a polish from the nail. Colour white; sometimes tinged yellow or red.

Variety 2. Indurated lithomarga.

Hardness 4 to 7. The softer sorts adhere very strongly to the tongue when newly broken; the harder very moderately. Colours grey, yellow, red, brown, blue.

A specimen of lithomarga from Osmund, analysed by Bergman, contained

60.0	silica,
11.0	alumina,
5.7	carbonat of lime,
4.7	oxide of iron,
0.5	carbonat of magnesia,
18.0	water and air.
99.9 *	

* Opusc. iv.

118 Bole.

Species 4. Bole.

Texture earthy. Fracture conchoidal. Lustre 0. Transparency scarce 1. Hardness 4. Sp. gr. from 1.4 to 2. Acquires a polish by friction. Scarcely adheres to the tongue. Feels greasy. Colour yellow or brown; sometimes red; sometimes spotted.

The lemnian earth which belongs to this species, according to the analysis of Bergman, contains

47,0	silica,
19,0	alumina,
6.0	carbonat of magnesia.
5.4	carbonat of lime,
5.4	oxide of iron,
17.0	water and air.
99.8 †	

† Ibid. p. 157.

119 Fullers earth.

Species 5. Fullers earth.

Texture earthy. Structure sometimes slaty. Fracture imperfectly conchoidal. Lustre 0. Opaque. Hardness 4. Receives a polish from friction. Does not adhere to the tongue. Feels greasy. Colour usually light green.

A specimen from Hampshire, analysed by Bergman, contained

51.8	silica,
25.0	alumina,
3.3	carbonat of lime,
3.7	oxide of iron,
0.7	carbonat of magnesia.
15.5	moisture.
100.0 ‡	

‡ Ibid. 159.

This

This earth is uſed by fullers to take the greaſe out of their cloth before they apply ſoap. It is eſſential to fullers earth that the particles of ſilica be very fine, otherwiſe they would cut the cloth. Any clay, poſſeſſed of this laſt property, may be conſidered as *fullers earth;* for it is the alumina alone which acts upon the cloth, on account of its ſtrong affinity for greaſy ſubſtances.

120 G. II. Colorific earths.

Genus II. Colorific Earths.

The minerals belonging to this genus conſiſt of clay, mixed with ſo large a quantity of ſome colouring ingredient as to render them uſeful as paints. The colouring matter is commonly oxide of iron, and ſometimes charcoal.

121 Red chalk.

Species 1. Red chalk.
Reddle.

Texture earthy. Fracture conchoidal. Luſtre 0. Opaque. Hardneſs 4. Sp. gr. inconſiderable. Colour dark red.

Feels rough. Stains the fingers. Adheres to the tongue. Falls to powder in water. Does not become ductile. When heated it becomes black, and at 159° Wedgewood melts into a greeniſh yellow frothy enamel.

Compoſed of clay and oxide of iron.

122 Yellow chalk.

Species 2. Yellow chalk.

Texture earthy. Fracture conchoidal. Hardneſs 3. Sp. gr. inconſiderable. Colour ochre yellow.

Feels ſmooth or greaſy. Stains the fingers. Adheres to the tongue. Falls to pieces in water. When heated becomes red; and at 156° Wedgewood melts into a brown porous porcelain.

According to Sage, it contains

50 alumina,
40 oxide of iron,
10 water, with ſome ſulphuric acid.
———
100 *

123 Black chalk.

Species 3. Black chalk.

Structure ſlaty. Texture earthy. Fragments ſplintery. Luſtre 0. Opaque. Hardneſs 5. Sp. gr. 2.144 to 2.277. Colour black. Streak black.

Feels ſmooth. Adheres ſlightly to the tongue. Does not moulder in water. When heated to redneſs it becomes reddiſh grey.

According to Wiegleb, it is compoſed of

64.50 ſilica,
11.25 alumina,
11.00 charcoal,
2.75 oxide of iron,
7.50 water.
———
97.00 †

124 Green earth.

Species 4. Green earth.

Texture earthy. Luſtre 0. Opaque. Hardneſs 6 to 7. Sp. gr. 2.637. Colour green.

Commonly feels ſmooth. Does not ſtain the fingers. Often falls to powder in water. When heated it becomes reddiſh brown; and at 147° Wedgewood melts into a compact glaſs.

Compoſed of clay, oxides of iron, and nickel.

125 G. III. Marl.

Genus III. Marl.

A mixture of carbonat of lime and clay, in which the carbonat conſiderably exceeds the other ingredient, is called *marl.*

Its texture is earthy. Luſtre 0. Opaque. Hardneſs from 4 to 8; ſometimes in powder. Sp. gr. from 1.6 to 2.877. Colour uſually grey, often tinged with other colours. Effervesces with acids.

Some marls crumble into powder when expoſed to the air; others retain their hardneſs for many years.

Marls may be divided into two ſpecies: 1. Thoſe which contain more ſilica than alumina; 2. Thoſe which contain more alumina than ſilica. Mr Kirwan has called the firſt of theſe *ſiliceous*, the ſecond *argillaceous*, marls. Attention ſhould be paid to this diſtinction, when marls are uſed as a manure.

Genus IV. Mould.

126 G. IV. Mould.

By *mould* is meant the ſoil on which vegetables grow. It contains the following ingredients: ſilica, alumina, lime, magneſia (ſometimes), iron, carbon derived from decayed vegetable and animal ſubſtances, carbonic acid, and water. And the good or bad qualities of *ſoils* depends upon a proper mixture of theſe ingredients. The ſilica is ſeldom in the ſtate of an impalpable powder, but in grains of a greater or ſmaller ſize: Its chief uſe ſeems to be to keep the ſoil open and pervious to moiſture. If we paſs over the carbon, the iron, and the carbonic acid, the goodneſs of a ſoil depends upon its being able to retain the quantity of moiſture which is proper for the nouriſhment of vegetables, and no more. Now the retentive power of a ſoil increaſes with the proportion of its alumina, lime, or magneſia, and diminiſhes as the proportion of its ſilica increaſes. Hence it follows, that in a dry country, a fertile ſoil ſhould contain leſs ſilica, and more of the other earths, than in a wet country.

Giobert found a fertile ſoil near Turin, where it rains annually 30 inches, to contain

From 77 to 79 ſilica,
9 — 14 alumina,
5 — 12 lime.

Near Paris, where it rains about 20 inches annually, Mr Tillet found a fertile ſoil to contain

Coarſe ſand 25
Fine ſand 21
— 46.0 ſilica,
16.5 alumina,
37.5 lime.
———
100.0 *

The varieties of mould are too numerous to admit an accurate deſcription: we ſhall content ourſelves, therefore, with mentioning the moſt remarkable.

127 Sand.

Species 1. Sand.

This conſiſts of ſmall grains of ſiliceous ſtones not cohering together, nor ſoftened by water. When the grains are of a large ſize, the ſoil is called *gravel.*

128 Clay.

Species 2. Clay.

This conſiſts of common clay mixed with decayed vegetable and animal ſubſtances.

129 Loam.

Species 3. Loam.

Any ſoil which does not cohere ſo ſtrongly as clay, but more ſtrongly than chalk, is called *loam.* There are many varieties of it. The following are the moſt common.

* *Mem. Par.* 1779, 313.

† *Ann. de Chim.* xxx. 13.

* *Kirwan on Manures.*

Variety

Earths and Stones.

Variety 1. Clayey loam; called alfo *ftrong*, *ftiff*, *cold*, and *heavy*, loam.

It confifts of a mixture of clay and coarfe fand.

Variety 2. Chalky loam.

A mixture of clay, chalk, and coarfe fand; the chalk predominating.

Variety 3. Sandy loam.

A mixture of the fame ingredients; the fand amounting to .8 or .9 of the whole.

130 Till.

SPECIES 4. Till.

Till is a mixture of clay and oxide of iron. It is of a red colour, very hard and heavy.

SECT II. *Aggregates of Amorphous Stones.*

THE aggregates which belong to this fection confift of amorphous fragments of ftones cemented together. They may be reduced to the following genera:

1. Sandftone,
2. Puddingftone,
3. Amygdaloid,
4. Breccia.

131 G. I. Sandftone.

GENUS I. SANDSTONE.

Small grains of fand, confifting of quartz, flint, hornftone, filiceous fhiftus, or felfpar, and fometimes of mica, cemented together, are denominated fandftones. They feel rough and fandy; and, when not very hard, eafily crumble into fand. The cement or bafis by which the grains of fand are united to each other is of four kinds; namely, lime, alumina, filica, iron. Sandftones, therefore, may be divided into four fpecies.

132 Calcareous.

SPECIES 1. Calcareous fandftones.

Calcareous fandftones are merely carbonat of lime or marl, with a quantity of fand interpofed between its particles. Though the quantity of fand, in many cafes, far exceeds the lime, calcareous fandftones are fometimes found cryftallized; and, in fome cafes, the cryftals, as might be expected, have fome of the forms which diftinguifh carbonat of lime. Thus the calcareous fandftone of Fountainbleau is cryftallized in rhomboidal tables. It contains, according to the analyfis of Laffone

62.5	filiceous fand,
37.5	carbonat of lime.
100	

Calcareous fandftones have commonly an earthy texture. Their furface is rough. Their hardnefs from 6 to 7. Their fpecific gravity about 2.5 or 2.6. Their colour grey; fometimes yellowifh or brown. They are fometimes burned for lime.

133 Aluminous.

SPECIES 2. Aluminous fandftones.

The bafis of argillaceous fandftones is alumina, or rather clay. Their ftructure is often flaty. Their texture is compact, and either fine or coarfe grained, according to the fize of the fand of which they are chiefly compofed. Their hardnefs is from 6 to 8, or even 9. Their colour is ufually grey, yellow, or brown.

They are often formed into mill-ftones, filtering-ftones, and coarfe whet-ftones.

134 Siliceous.

SPECIES 3. Siliceous fandftones.

Siliceous fandftones confift of grains of fand cemented together by filica, or fome fubftance which confifts chiefly of filica or flint. They are much harder than any of the other fpecies.

Sometimes ftones occur, confifting of grains of lime cemented together with filica. Thefe ftones are alfo denominated filiceous fandftones. Aggregates

135 Ferruginous.

SPECIES 4. Ferruginous fandftones.

The iron which acts as a cement in ferruginous fandftones is not far from a metallic ftate. When iron is completely oxidated, it lofes the property of acting as a cement. This is the reafon that ferruginous fandftones, when expofed to the air, almoft always crumble into powder.

The colour of ferruginous fandftones is ufually dark red, yellow, or brown. The grains of fand which compofe them are often pretty large. Their hardnefs is commonly inconfiderable.

136 G. II. Pudding ftone.

GENUS II. PUDDING STONE.

Pebbles of quartz, flint, or other fimilar ftones of a round or eliptical form, from the fize of rape feed to that of an egg, cemented together by a filiceous cement, often mixed with iron, have been denominated *pudding ftones*.

Pudding ftones, of courfe, are not inferior in hardnefs to quartz, flint, chalcedony, &c. of which the pebbles may confift. The colour of the cement is ufually yellow, brown, or red. Its fracture is conchoidal.

The finer forts of pudding ftones are capable of a fine polifh; the coarfe are ufed for mill-ftones.

137 G. III. Amygdaloid.

GENUS III. AMYGDALOID.

Rounded or eliptical maffes of chalcedony, zeolite, limeftone, lithomarga, fteatites, green earth, garnets, hornblende, or opal, cemented together by a bafis of indurated clay, trap, mullen, walken or kragg, conftitute an *amygdaloid*.

Amygdaloids are opaque. They have no luftre. Their fracture is uneven or conchoidal. Hardnefs 6 to 9. Their colours are as various as the ingredients of which they are compofed.

138 G. IV. Breccia.

GENUS IV. BRECCIA.

Angular fragments of the fame *fpecies* of ftone, agglutinated together, conftitute a *breccia*. This *calcareous* breccia confifts of fragments of marble cemented together by means of lime.

SECT. III. *Aggregates of Cryftals.*

THE minerals belonging to this fection confift either of cryftals of different kinds cemented together, or of cryftals and amorphous ftones cemented together.

They may be reduced under the following genera.

1. Granite,
2. Sienite,
3. Granatine,
4. Granitell,
5. Granilite,
6. Trap,
7. Porphyry.

139 G. I. Granite.

GENUS I. GRANITE.

An aggregate of felfpath, quartz, and mica, whatever be the fize or the figure of the ingredients, is denominated *granite*. This aggregate may be divided into two fpecies, namely, *common* granite, and *fhiftofe* granite or gneifs.

140 Common.

SPECIES 1. Common granite.

Its ftructure is always granular. The felfpar is often amor-

Earths and Stones. amorphous, and conſtitutes moſt frequently the greateſt part of the aggregate.

Common granites differ much in their appearance, according to the ſize, proportion, colour, and figure of their component parts. They are commonly very hard: Their ſpecific gravity varies from 2.5388 to 2.9564.

141 Gneiſs.

SPECIES 2. Shiſtoſe granite or gneiſs.

The ſtructure of gneiſs is always ſlaty, and this conſtitutes its ſpecific character. In gneiſs, the proportion of quartz and felſpar is nearly equal: the proportion of mica is ſmalleſt. It is evidently ſubject to the ſame varieties with common granite.

142 G. II. Sienite.

GENUS II. Sienite.

Mr Werner has given the name of *ſienite* to aggregates compoſed of felſpar, hornblende, and quartz; or of felſpar, hornblende, quartz, and mica. Theſe aggregates were formerly confounded with quartz.

Sienite is found both of a granular and ſlaty ſtructure: it might, therefore, like granite, be divided into two ſpecies. In ſienite the quartz is commonly in by far the ſmalleſt proportion.

143 G. III. Granatine.

GENUS III. GRANATINE.

Mr Kirwan has applied the name *granatine* to the following aggregates.

Quartz, Felſpar, Shorl.	Quartz, Mica, Garnet.	Quartz, Hornblende, Jade.	Felſpar, Mica, Shor
Quartz, Felſpar, Jade.	Quartz, Shorl, Hornblende.	Quartz, Hornblende, Garnet.	Felſpar, Mica, Hornblende.
Quartz, Felſpar, Garnet.	Quartz, Shorl, Jade.	Quartz, Jade, Garnet.	Felſpar, Quartz, Serpentine.
Quartz, Mica, Shorl.	Quartz, Shorl, Garnet.	Quartz, Hornblende, Hornſtone,	Felſpar, Quartz, Steatites.
Quartz, Mica, Jade.			

One of theſe aggregates, namely, *quartz*, *mica*, *garnet*, was called by Cronſtedt *morka* or *murkſten*.

144 G. IV. Granitell.

GENUS IV. GRANITELL.

Mr Kirwan gives the name of *granitell* to all aggregates compoſed of any two of the following ingredients: quartz, felſpath, mica, ſhorl, hornblende, jade, garnet, ſteatites. The moſt remarkable of theſe are:

Quartz, Felſpar.	Quartz, Hornblende.	Quartz, Steatites.	Felſpar, Hornblende.
Quartz, Mica.	Quartz, Jade.	Felſpar, Mica.	Felſpar, Jade.
Quartz, Shorl.	Quartz, Garnet.	Felſpar, Shorl.	Felſpar, Garnet.

Aggregates

Mica, Shorl.	Mica, Jade.	Hornblende, Jade.	Jade, Garnet.
Mica, Hornblende,	Mica, Garnet.	Hornblende, Garnet.	Steatites, Shorl.

Some of theſe aggregates have received particular names. The aggregate of *quartz* and *mica*, when its ſtructure is ſlaty, is called by Werner *ſhiſtoſe mica*: by the Swedes, it is denominated *ſtellſten*, whatever be its ſtructure.

The aggregate of hornblende and mica is called *grunſtein*, from the dark green colour which it uſually has.

145 G. V. Granilite.

GENUS V. GRANILITE.

Under the name of *granilite*, Mr Kirwan comprehends all aggregates containing more than three ingredients. Of theſe the following are the moſt remarkable.

Quartz, Felſpar, Mica, Shorl.	Quartz, Mica, Shorl, Garnet.	Quartz, Sulph. of barytes, Mica, Shorl.
Quartz, Felſpar, Mica, Steatites.	Quartz, Felſpar, Mica, Garnet.	Quartz, Sulph. of barytes, Mica, Hornblende.

146 G. VI. Trap.

GENUS VI. TRAP (P).

Under this genus we claſs not only what has commonly been called *trap*, but alſo wacken, and mullen, and kragſtone of Kirwan.

147 Common.

SPECIES 1. Common trap.

This ſtone is very common in Scotland, and is known by the name of *whinſtone*. Whole hills are formed of it; and it occurs very frequently in large rounded detached fragments. Sometimes it aſſumes the form of immenſe columns, and is then called *baſalt*. The Giants Cauſeway in Ireland, the iſland of Staffa, and the ſouth ſide of Arthur's Seat in Scotland, are well known inſtances of this figure.

Its texture is earthy or compact. Its fracture uneven. Its luſtre commonly 0. Opaque. Hardneſs 8 to 9. Not brittle. Sp. gr. from 2.78 to 3.021 *. Colour black, with a ſhade of grey, blue, or purple; ſometimes blackiſh or reddiſh brown; in ſome caſes greeniſh grey. By expoſure to the atmoſphere, it often becomes inveſted with a browniſh rind. Before the blow-pipe, it melts *per ſe* into a more or leſs black glaſs.

* *Kirwan.*

Trap conſiſts of ſmall cryſtals of hornblende, felſpar, olivine, &c. uſually ſet in a ground compoſed apparently of clay and oxide of iron. A ſpecimen, in the form of baſaltes, from Staffa, analyſed by Dr Kennedy of Edinburgh, contained

48 ſilica,
16 alumina,
16 oxide of iron,
9 lime,
5 moiſture,
4 ſoda,
1 muriatic acid.

99 †

† *Edin. Tranſ.* v. 89.

A

(P) *Kirw.* I. 231 and 431.—*Faujas de St Fond. Eſſai ſur l'Hiſt. Nat. des Roches de Trap.*—*Phil. Tranſ.* paſſim. See alſo a very ingenious ſet of experiments on the fuſion of trap, by Sir James Hall in *Tranſ. Edin.* V. 43.

Earths and Stones.

A specimen from Salisbury rock, near Edinburgh, contained, according to the analysis of the same gentleman,

46.0	silica,
19.0	alumina,
17.0	oxide of iron,
8.0	lime,
4.0	moisture,
3.5	soda,
1.0	muriatic acid.
98.5 *	

* Edin. Trans. v. 90.

Dr Kennedy conducted these analyses with great ingenuity and judgment; and the discovery in which they terminated, that trap contains soda, is certainly of importance, and may lead to valuable consequences both in a geological and mineralogical view.

148 Wacken.

SPECIES 2. Wacken †.

† Kirwan, i. 223.

‡ Kirwan.

This stone often forms considerable parts of hills, and, like trap, is amorphous. Its texture is earthy. Its fracture usually even. Lustre 0. Opaque. Hardness 6 to 9. Sp gr. from 2.535 to 2.893 ‡. Colour grey, with a shade of green, black, red, brown. When exposed to the atmosphere, it withers and becomes more grey.

It melts into a grey porous slag.

149 Mullen.

SPECIES 3. Mullen *.

* Kirwan, i. 225.

This stone is also found in considerable masses, and sometimes has a tendency to a columnar form like basalt. Texture earthy. Fracture uneven, and fine splintery. Lustre 0, except from some shining particles of basaltine. Opaque. Hardness from 7 to 9. Sp. gr. from 2.6 to 2.738. Colour ash or bluish grey; sometimes mixed with ochre yellow, in consequence of the decomposition of the stone. At 130° Wedgewood it melts into a black compact glass.

When mullen is exposed to the air, its surface becomes covered with a greyish white rind sometimes slightly ochry.

150 Kragstone.

SPECIES 4. Kragstone *.

* Kirw. i. 226.

This stone, which, like the others, forms considerable parts of rocks, was formed into a distinct species by Mr Kirwan. It's texture is earthy. It is exceedingly porous, and the pores are often filled with the crystals of other minerals. Fracture uneven. Lustre 0. Opaque. Hardness 5 to 7. Sp. gr. 2.314. Feels rough and harsh. Colour reddish grey. Streak yellowish grey. At 138° Wedgewood it melts into a reddish brown porcelain mass.

151 G. VII. Porphyry.

GENUS VII. PORPHYRY.

Any stone which contains scattered crystals or grains of felspar, visible to the naked eye, is denominated a *porphyry*. Besides felspar, porphyries generally contain small crystals of quartz, hornblende, and mica. These crystals are usually of a different colour from the stone in which they are found, and they are stuck in it as in a cement. It is evident from this definition, that the number of porphyries must be great. Each species receives its name from the stone which forms its basis. To describe them would be unnecessary. We shall only give a catalogue of the principal species.

Aggregate.

1. Hornstone porphyry.	8. Wacken porphyry.
2. Pitchstone porphyry.	9. Mullen porphyry.
3. Hornslate porphyry.	10. Krag porphyry.
4. Felspar or petunse porphyry.	11. Argillitic porphyry.
5. Clay porphyry.	12. Potstone porphyry.
6. Hornblende porphyry.	13. Serpentine porphyry.
7. Trap porphyry.	14. Sandstone porphyry.

The aggregates belonging to this section compose most of the mountains of the globe. In giving an account of them, we have adhered implicitly to the arrangement most generally received by mineralogists. It must be acknowledged, that this arrangement is by no means complete, and that some of the genera are too vague to be of much use. The number of aggregates already discovered is too great for giving to each a particular name. Perhaps it would be better henceforth to adopt the method proposed by Mr Hauy, namely, to constitute the genera from that ingredient which enters most abundantly into the aggregate, and which forms as it were its basis, and to distinguish the species according to the nature and proportion of the other ingredients. According to this plan, the aggregates hitherto discovered have been divided by Hauy into the following genera:

1. Felspathic rock.	7. Hornblendean rock.
2. Quartzous rock.	8. Petro siliceous rock.
3. Micaceous rock.	9. Garnetic rock.
4. Chloritous rock.	10. Calcareous rock.
5. Serpentine rock.	11. Argillaceous rock.
6. Trappean rock.	12. Corneous rock.

SECT. IV. *Volcanic Aggregates.*

AGGREGATES formed by volcanoes may be reduced to the following genera.

1. Lava.
2. Tufa.
3. Pumice.
4. Ashes.

GENUS I. LAVA. 152 G. I. Lava.

All substances which have issued out of a volcano in a state of fusion are called *lavas*. They have been divided into three species.

SPECIES 1. Vitreous lava. 153 Vitreous.

Found in small pieces.

Texture glossy. Fracture conchoidal. Lustre 3. Transparency from 3 to 1. Hardness 9 to 10. Sp. gr. from 2 to 3. Colour blackish, greenish, or whitish. Commonly somewhat porous.

SPECIES 2. Cellular lava. 154 Cellular.

This species is full of cells. Surface rough and full of cavities. Texture earthy. Lustre 0. Opaque. Hardness 7 to 9. Sp. gr. varies, but does not exceed 2.8. Colour brown or greyish black. Commonly somewhat magnetic.

SPECIES 3. Compact lava. 155 Compact.

This species is the most common of all; it runs into the

Combuſtibles.

the ſecond by inſenſible degrees; and indeed is ſeldom found of any conſiderable ſize without ſome pores. It bears in general a very ſtrong reſemblance to trap.

A ſpecimen of the lava of Catania in Sicily, analyſed by Dr Kennedy, contained

51.0 ſilica,
19.0 alumina,
14.5 oxide of iron,
9.5 lime,
4.0 ſoda,
1.0 muriatic acid.
———
99.0 *

A ſpecimen of the lava of Sta. Venere in Sicily he found to contain

50.75 ſilica,
17.50 alumina,
14.25 oxide of iron,
10.00 lime,
4.00 ſoda,
1.00 muriatic acid.
———
97.5 †

Thus we ſee, that the reſemblance between trap and lava holds not only in their external appearance, but alſo in their component parts.

* Tranſ. Edin. v. 93.

† Ibid. 94.

Combuſtible.

156 G. II. Puzzolana.

Genus II. puzzolana.

Found in ſmall pieces. Surface rough. Texture earthy and porous. Fracture uneven. Luſtre 0. Opaque. Hardneſs 3. Very brittle. Sp. gr. from 2.57 to 2.8. Colour brown or dark grey. Magnetic. Eaſily melts into a black ſlag.

When mixed with lime into a mortar, it poſſeſſes the property of hardening even under water. This property it owes moſt probably, as Mr Kirwan ſuppoſes, to the iron which it contains. The iron decompoſes the water of the mortar, and by this means it becomes too hard to be acted upon by water in a very ſhort time.

157 G. III. Pumice.

Genus III. pumice.

This is a very light ſubſtance ejected from volcanoes. It is porous. Hardneſs 3. Brittle. Sp. gr. below 1. Colour grey or brown.

In ſome varieties the luſtre and tranſparency are 0: in others, the luſtre is glaſſy, 2. Tranſparency from 1 to 2.

158 G. IV. Volcanic aſhes.

Genus IV. volcanic ashes.

Theſe are analogous to the aſhes of common pit coal. Looſe and ſmooth, very light and fine. Slowly diffuſible in water, and when wet ſomewhat ductile.

Class II. SALTS.

UNDER this claſs we comprehend all the combinations of alkalies with acids which exiſt in the mineral kingdom. As they have been already deſcribed in the article Chemistry, Suppl. we ſhall here only give a liſt of their names.

159 Genera.

Genus I. potass.

Sp. 1. Sulphat of potaſs.
2. Nitrat of potaſs.

Genus II. soda.

Sp. 1. Carbonat of ſoda.
2. Sulphat of ſoda.
3. Muriat of ſoda.
4. Borax.

Genus III. ammonia.

Sp. 1. Sulphat of ammonia.
2. Muriat of ammonia.

Class III. COMBUSTIBLES.

160 Genera.

THE combuſtible ſubſtances belonging to the mineral kingdom, excluding the metals, may be comprehended under the following genera.

1. Sulphur.
2. Carbon.
3. Bitumen.
4. Coal.
5. Amber.

161 G. I. Sulphur.

Genus I. sulphur.

species 1. Native ſulphur.

This ſubſtance is found abundantly in many parts of the world, eſpecially near Volcanoes, as Hecla, Ætna, Veſuvius, the Lipari iſlands, &c. It is either in the ſtate of powder, or maſſive, or cryſtallized. The primitive form of its cryſtals is an octohedron, compoſed of two four-ſided pyramids, joined baſe to baſe ‡. The ſides of theſe pyramids are ſcalene triangles, and ſo inclined that the plane where the baſes of the pyramids join in a rhomb, whoſe long diagonal is to its ſhort as 5 to 4 §. Sometimes the apices of the pyramids, to uſe the language of De Liſle, are truncated; ſometimes they are ſeparated from each other by a priſm; ſometimes they are truncated near their baſes, and a low four-ſided pyramid riſes from the truncature: this pyramid is alſo ſometimes truncated near its apex ¶. Finally, one of the edges of the pyramids is ſometimes truncated. For figures of theſe varieties and for the laws of their formation, we refer to *Mr Lefroy* *.

Colour yellow, with a ſhade of green; ſometimes reddiſh (q). Luſtre greaſy, 2. Tranſparency varies from 0 to 4. Cauſes double refraction †. Texture compact. Hardneſs 4 to 5. Brittle.—For its other properties, we refer to Chemistry in this *Suppl.*

Sometimes ſulphur is mixed with different proportions of earths. Theſe combinations are hardly ſuſceptible of accurate deſcription.

Sulphur combines alſo with metals. Theſe combinations ſhall be deſcribed in the fourth claſs.

‡ Fig. 34.

§ *Romé de Liſle*, i. 292. *Hauy* and *Lefroy*, *Jour. de Min.* No xxix. 337.

¶ Fig. 35.

* *Jour. de Min.* No xxix. 337.

† *Hauy.*

162 G. II. Carbon.

Genus II. carbon.

This genus comprehends all minerals compoſed of pure carbon, or of carbon combined with a little earth.

163 Diamond.

species 1. Diamond.

This mineral, which was well known to the ancients, is

(q) It then contains arſenic.

Combuftibles. is found in different parts of Afia, particularly in the kingdoms of Golconda and Vifapour; it is found alfo in Brazil.

It is always cryftallized; but fometimes fo imperfectly, that at the firft fight it might pafs for amorphous. Its primitive form is a regular octogon †; but it more commonly affumes a fpheroidal form, and then has ufually 36 curvilinear triangular faces, fix of which are raifed upon each of the faces of the primitive octogon ‡. Its integrant molecule, according to Hauy, is a regular tetrahedron.—For a more particular account of the cryftals of this mineral, we refer the reader to *Mr Romé de Lifle* * and *Mr Hauy* †.

† Fig. 36. ‡ Fig. 37. * *Cryftal.* ii. 191. † *Jour. de Min.* N° xxix. 343. ‡ *Hauy, ibid.*

Texture foliated. Luftre 4. Tranfparency from 2 to 4. Caufes fingle refraction. Hardnefs 20. Sp. gr. 3.5185 to 3.5310 ‡. Colour various; fometimes limpid, fometimes red, orange, yellow, green, blue, and even blackifh.

When rubebd it becomes pofitively electric, even before it has been cut by the lapidary, which is not the cafe with any other gem ‖.

‖ *Id. ibid.*

It is compofed of pure carbon §.

§ *Morveau, Ann. de Chim.* xxxi. 72.

164 Mineral charcoal.

SPECIES 2. Mineral charcoal.

Kilkenny coal—Wales culm.

This mineral has been found in Hungary, Italy, France, Ireland, and Wales. It occurs in ftratified maffes, or in lumps nefted in clay.

Colour black. Luftre 4, metallic. Opaque. Texture foliated. Hardnefs 5 to 7. Sp. gr. 1.4 to 1.526, Often ftains the fingers. Infoluble in acids. Deflagrates with nitre. Does not born till wholly ignited, and then confumes flowly without emitting flame or fmoke.

It confifts almoft entirely of *charcoal*, which, as Morveau has proved, is an oxide of carbon *.

* *Ibid.*

165 Anthracite.

SPECIES 3. Anthracite (R).

Anthracolite.

This fubftance, as Dolomieu informs us, is found exclufively in the primitive mountains. It is always amorphous. Colour black or brownifh black. Luftre 3 to 4. Structure flaty. Fragments rhomboidal. Hardnefs 6 to 7. Sp. gr. greater than that of coal. Often ftains the fingers.

Burns precifely like the laft fpecies, and leaves .40 of white afhes. According to Dolomieu, it is compofed of about

64.0	charcoal,
32.5	filica,
3.5	iron,
100.0 †	

† *Jour. de Min.* N° xxix. 338.

It is probable that the charcoal in the two laft fubftances is in the fame ftate in which it exifts in plumbago, combined with oxygen, but not containing fo much as charcoal does ‡.

‡ *Morveau, ibid.*

166 G. III. Bitumen.

GENUS III. BITUMEN.

By bitumen we underftand, with mineralogifts in general, an oil, which is found in different parts of the earth, in various ftates of confiftence. Thefe different ftates form diftinct fpecies; in our arrangement of which we fhall be guided by the obfervations which Mr Hatchett has made in his valuable paper on bituminous fubftances *.

* *Nicholfon's Journal*, ii. 201, 248.

(R) This name was given by Hauy from ανθραξ, *a coal.*

167 Naphtha.

SPECIES 1. Naphtha.

This fubftance is found fometimes on the furface of the water of fprings, and fometimes iffuing from certain ftrata. It is found in great abundance in Perfia.

It is as fluid and tranfparent as water. Colour white or yellowifh white. Smell ftrong, but not difagreeable. Sp. gr. when white, .708 * or .729 †; when yellowifh, .8475 ‡. Feels greafy. Catches fire on the approach of flame, burns with a white flame, and leaves fcarce any refiduum.

* *Mufchenbroek.* † *Boulduc.* ‡ *Briffon.*

Infoluble in alcohol. Does not freeze at 0° Fahrenheit. When pure naphtha is expofed to the air, it becomes yellow and then brown; its confiftence is increafed, and it paffes into *petroleum* *.

* *Hatchett.*

168 Petroleum.

SPECIES 2. Petroleum.

This fubftance is alfo found in Perfia, and likewife in many countries in Europe, particularly Italy, France, Switzerland, Germany, Sweden, England, and Scotland.

Not fo fluid nor tranfparent as water. Colour yellow, either pale or with a fhade of red or green; reddifh brown and reddifh black. Smell that of naphtha, but lefs pleafant. Sp. gr. 8783 *. When burned it yields a foot, and leaves a fmall quantity of coally refiduum.

* *Briffon.*

By expofure to the air it becomes like tar, and is then called *mineral tar* †.

† *Hatchett, ibid.*

169 Mineral tar.

SPECIES 3. Mineral tar.

This fubftance is found in many parts of Afia, America, and Europe. It is vifcid, and of a black, brownifh black, or reddifh colour. Smell fometimes ftrong, but often faint. Sp. gr. 1.1. When burned, emits a difagreeable bituminous fmell. By expofure to the air it paffes into *mineral pitch* and *maltha* *.

* *Hatchett, ibid.*

170 Mineral pitch and maltha.

SPECIES 4. Mineral pitch and maltha.

This fubftance has a ftrong refemblance to common pitch. When the weather is warm it is foft, and has fome tenacity; it is then called *adhefive mineral pitch*: when the weather is cold, it is brittle; its hardnefs is 5; and its fracture has a glaffy luftre. In this ftate it is called *maltha*. Colour black, dark brown, or reddifh. Luftre 0. Opaque. Sp. gr. from 1.45 to 2.07. Does not ftain the fingers. On a white hot iron it flames with a ftrong fmell, and leaves a quantity of grey afhes. It it is to the prefence of the earths which compofe thefe afhes that the great fpecific gravity of this bitumen is to be afcribed. By farther induration, it paffes into *afphalt.*

171 Afphalt.

SPECIES 5. Afphalt.

This fubftance is found abundantly in many parts of Europe, Afia, and America, efpecially in the ifland of Trinidad.

Colour black or brownifh black. Luftre greafy 2. Opaque. Fracture conchoidal, of a glaffy luftre. Hardnefs from 7 to 8. Very brittle. Sp. gr. 1.07 to 1.165 *. Feel fmooth, but not greafy. Does not ftain the fingers. Has little or no fmell, unlefs when rubbed or heated. When heated melts, fwells, and inflames; and when pure, burns without leaving any afhes.

* *Kirwan.*

172 Elaftic bitumen.

SPECIES 6. Elaftic bitumen.

Mineral caoutchouc.

This fubftance was found about the year 1786 in the lead

Combuſtibles. lead mine of Odin, near Caſtletown, Derbyſhire. It was firſt mentioned by Mr De Born.

Colour yellowiſh or reddiſh brown, ſometimes blackiſh brown. In its appearance it has a ſtrong reſemblance to caoutchouc or Indian rubber; hence its name. Conſiſtency various: ſometimes ſo ſoft as to adhere to the fingers; ſometimes nearly as hard as aſphalt. When ſoft it is elaſtic; when hard brittle. Sp. gr. 0.9053 to 1.0233 *.

* *Hatchett, ibid.*

Inſoluble in alcohol, ether, and oil of turpentine, but ſoluble in oil of olives. Not affected by nitric acid. When diſtilled, it yields a bituminous oil inſoluble in alcohol; the reſiduum is carbonaceous †.

† *Lametherie, Jour. de Phyſ.* xxxi. 312.

There is a variety of this ſubſtance found in a rivulet near the mine of Odin, which, when freſh cut, exactly reſembles fine cork in colour and texture; but in a few days after being expoſed to the air, becomes of a pale reddiſh brown. This ſubſtance contains within it a nucleus of elaſtic bitumen. It ſeems to be the elaſtic bitumen altered in its texture by the water ‡.

‡ *Hatchett, ibid.*

173 G. IV. Coal.

Genus IV. coal.

The ſubſtances belonging to this genus are compoſed of carbon, or rather charcoal, and bitumen.

174 Jet.

Species 1. Jet (s).

This ſubſtance is found in France, Spain, Germany, Britain, and other countries. It is found in detached kidneyform maſſes, of various ſizes, from an inch to ſeven or eight feet in length.

Colour full black. Luſtre 3 to 4; internal glaſſy. Opaque. Hardneſs 7 to 8. Not near ſo brittle as aſphalt. Texture ſtriated. Fracture conchoidal. Sp. gr. 1.259 *. It has no odour except when heated, and then it reſembles the odour of aſphaltum. Melts in a ſtrong heat, burns with a greeniſh flame, and leaves an earthy reſiduum †. Becomes ſomewhat electric by friction ‡. When diſtilled yields a peculiar acid §.

* *Briſſon.* † *Hatchett.* ‡ *Kirwan.* § *Vauquelin.*

This mineral is formed into buttons, beads, and other trinkets. The manufacture has been almoſt confined to France ‖.

‖ *Jour. de Min.* N° iv. 41.

175 Cannel coal.

Species 2. Cannel coal.

This mineral is found in Lancaſhire, and in different parts of Scotland, where it is known by the name of *parrot coal.*

Colour black. Luſtre common, 2. Opaque. Structure ſometimes ſlaty. Texture compact. Fracture conchoidal. Hardneſs 5 to 8. Brittle. Sp. gr. 1.232 to 1.426. Does not ſtain the fingers.

Kindles eaſily, and burns with a bright white flame like a candle (T), which laſts but a ſhort time. It does not cake. It leaves a ſtony or ſooty reſiduum.

A ſpecimen of Lancaſhire cannel coal, analyſed by Mr Kirwan, contained 75.20 charcoal,
21.68 maltha,
3.10 alumina and ſilica.

99.98 ¶

¶ *Mineral.* ii. 523.

A ſpecimen of the ſlaty kind from Airſhire, called *ſplent coal*, was compoſed of
47.62 charcoal,
32.52 maltha,
20.00 earths.

100.14 *

* *Ibid.* 524

Cannel coal is ſuſceptible of poliſh, and, like jet, is often wrought into trinkets.

176 Common coal.

Species 3. Common coal.

This very uſeful combuſtible is never found in the primitive mountains, but only in the ſecondary mountains, or in plains formed of the ſame materials with them. It is always in ſtrata, and generally alternates with clay, ſandſtone, or limeſtone.

Colour black, more or leſs perfect. Luſtre uſually greaſy or metallic, 2 to 4. Opaque. Structure generally ſlaty. Texture often foliated. Fracture various. Hardneſs 4 to 6. Sp. gr. 1.25 to 1.37. Uſually ſtains the fingers. Takes fire more ſlowly, and burns longer, than the laſt ſpecies. Cakes more or leſs during combuſtion.

Of this ſpecies there are many varieties, diſtinguiſhed in Britain by the names of caking coal, rock coal, &c. Theſe are too well known to require any deſcription.

Mr Kirwan analyſed a variety of different kinds of coal: The reſult of his experiments may be ſeen by the following table.

Whitehaven coal.	Wigan.	Swanſey.	Leitrem.	
57.0	61.73	73.53	71.43	charcoal.
41.3	36.7	23.14	23.37	maltha & aſph.
1.7	1.57	3.33	5.20	earths †.
100.0	100.00	100.00	100.00	

† *Mineral,* ii. 525.

177 Spurious coal.

Species 4. Spurious coal.

This mineral is generally found amidſt ſtrata of genuine coal. It is alſo called *parrot-coal* in Scotland.

Colour greyiſh black. Luſtre 0 to 1. Structure uſually ſlaty. Texture earthy. Hardneſs 7 to 8. Sp. gr. 1.5 to 1.6. Generally explodes, and burſts when heated.

Compoſed of charcoal, maltha, and aſphalt, and above .20 of ſtony matter.

178 G. V. Amber.

Genus V. amber.

Species 1. Common amber.

This ſubſtance, called *electrum* by the ancients, is found in different countries; but moſt abundantly in Pruſſia, either on the ſea-ſhore, or under-ground at the depth of about 100 feet, repoſing on *wood-coal* ‡. It is in lumps of different ſizes.

‡ *Kirw. Min.* ii. 66.

Colour yellow. Luſtre 3 to 2. Tranſparency 2 to 4. Fracture conchoidal. Hardneſs 5 to 6. Sp. gr. 1.078 to 1.085. Becomes electric by friction.

If a piece of amber be fixed upon the point of a knife, and then kindled, it burns to the end without melting ¶.

¶ *Hauy.*

By diſtillation it yields ſuccinic acid.

Class

(s) It was called *gagathes* by the ancients, from the river Gages in Licia, near which it was found; *jayet* in French, *azabache* in Spaniſh, *gagath* in German.

(T) Hence it has been called *cannel coal.* *Candle*, in the Lancaſhire and Scotch dialect, is pronounced *cannel.*

Class IV. METALLIC ORES.

THIS clafs comprehends all the mineral bodies, compofed either entirely of metals, or of which metals conftitute the moft confiderable and important part. It is from the minerals belonging to this clafs that all metals are extracted; for this reafon they have obtained the name of *ores*.

179 Orders. The metals hitherto difcovered amount to 21; we fhall therefore divide this clafs into 21 orders, allotting a diftinct order for the ores of every particular metal.

Metals exift in ores in one or other of the four following ftates: 1. In a metallic ftate, and either folitary or combined with each other. 2. Combined with fulphur. 3. In the ftate of oxides. 4. Combined with acids. Each order therefore may be divided into the four following genera.

180 Genera.

1. Alloys,	3. Oxides,
2. Sulphurets,	4. Salts.

It muft be obferved, however, that every metal has not hitherto been found in all thefe four ftates, and that fome of them are hardly fufceptible of them all. Some of the orders therefore want one or more genera, as may be feen from the following table.

Order I. *Gold ores.*
1. Alloys.

Order II. *Silver ores.*
1. Alloys.
2. Sulphurets.
3. Oxides.
4. Salts.

Order III. *Platinum ores.*
1. Alloys.

Order IV. *Ores of mercury.*
1. Alloys.
2. Sulphurets.
3. Oxides.
4. Salts.

Order V. *Copper ores.*
1. Alloys.
2. Sulphurets.
3. Oxides.
4. Salts.

Order VI. *Iron ores.*
1. Alloys.
2. Sulphurets.
3. Carburets.
4. Silicated iron.
5. Oxides.
6. Salts.

Order VII. *Tin ores.*
1. Sulphurets.
2. Oxides.

Order VIII. *Lead ores.*
1. Sulphurets.
2. Oxides.
3. Salts.

Order IX. *Zinc ores.*
1. Sulphurets.
2. Oxides.
3. Salts.

Order X. *Antimonial ores.*
1. Alloys.
2. Sulphurets.
3. Oxides.
4. Salts.

Order XI. *Bifmuth ores.*
1. Alloys.
2. Sulphurets.
3. Oxides.

Order XII. *Arfenic ores.*
1. Alloys.
2. Sulphurets.
3. Oxides.

Order XIII. *Cobalt ores.*
1. Alloys.
2. Sulphurets.
3. Oxides.
4. Salts.

Order XIV. *Nickel ores.*
1. Sulphurets.
2. Oxides.
3. Salts.

Order XV. *Manganefe ores.*
1. Oxides.
2. Salts.

Order XVI. *Tungsten ores.*
1. Oxides.
2. Salts.

Order XVII. *Ores of molybdenum.*
1. Sulphurets.

Order XVIII. *Ores of uranium.*
1. Oxides.
2. Salts.

Order XIX. *Ores of titanium.*
1. Oxides.

Order XX. *Ores of tellurium.*
1. Alloys.

Order XXI. *Ores of chromum.*
1. Oxides.

Order I. GOLD ORES.

No metal perhaps, if we except iron, is more widely fcattered through the mineral kingdom than gold *. Hitherto it has been found only in a metallic ftate; moft commonly in grains, ramifications, leaves, or rhomboidal, octahedral, or pyramidal cryftals. It is generally mixed with quartz, though there are inftances of its having occurred in calcareous rocks. It is not uncommon alfo to find it differminated through the ores of other metals; efpecially iron, mercury, copper, and zinc. The greateft quantity of gold is found in the warmer regions of the earth. It abounds in the fands of many African rivers, and is very common in South America and India. Europe, however, is not deftitute of this metal. Spain was famous in ancient times for its gold mines, and feveral of the rivers in France contain it in their fands †. But the principal gold mines in Europe are thofe of Hungary, and next to them thofe of Salzburg. Gold alfo has been difcovered in Sweden and Norway, and more lately in the county of Wicklow in Ireland ‡. 181 Where found.

* Bergman.

† Reaumur, Mem. Par. 1718, p. 68.

‡ Lloyd, Phil Tranf. 1796, p. 36. Mills, ibid. p 38 —Nicholfon's Journ. ii. 224.

Genus I. Alloys of gold.

Species 1. Native gold.

Native gold is never completely pure; it is alloyed with fome filver or copper, and fometimes with iron. In the native gold found in Ireland, indeed, the quantity of alloy appears to have been exceedingly fmall. 182 G.I. Native gold.

Its colour is yellow. Luftre metallic. Fracture hackly. Hardnefs 5. Sp. gr. from 12 to 19.

Order II. SILVER ORES.

Silver is found moft commonly in quartz, limeftone, hornftone; or combined with the ores of other metals, moft commonly with copper, antimony, zinc, cobalt, and lead. This laft metal indeed is feldom totally deftitute of filver. 183 Where found.

Genus I. Alloys of filver.

Species 1. Native filver *.

Native filver, fo called becaufe the filver is nearly in a ftate of purity, forms the principal part of fome of the richeft filver mines in the world. It is fometimes in fmall lumps; fometimes cryftallized in cubes, hexahedrons, octahedrons, or dodecahedrons; fometimes in leaves, or threads, often fo connected with each other as to refemble branches of trees, and therefore called *dendrites*. The filver in the famous mines of Potofi has this laft form. When newly extracted, it is not unlike fmall branches of fir †. 184 G.I. Native filver.

The colour of native filver is white; often tarnifhed. Luftre metallic. Fracture hackly. Hardnefs 6. Malleable. Sp. gr. from 1 to 10.338.

The filver in this fpecies is almoft conftantly alloyed with from .03 to .05 of fome other metal, frequently gold or arfenic.

* Kirw. ii. 108.—Catling. Act. Liter. Svecia, 1738, p. 20.

† Bergman's Phyf. Geogr. Jour. de Min. No xvi p. 26.

Silver.

185 Alloy of silver and gold.

SPECIES 2. Alloy of silver and gold.

Auriferous native silver.

This alloy is not uncommon in silver mines. Its colour is yellowish white. Its lustre metallic. Hardness 5. Malleable. Sp. gr. above 10.6. Dr. Fordyce found a specimen from Norway composed of

72 silver,
28 gold.

100 *

* *Phil. Transf.* 1776, p. 532.

SPECIES 3. Alloy of silver and antimony †.

Antimoniated silver ore.

186 Alloy of silver and antimony. This alloy, which is found in the silver mines of Spain and Germany, is sometimes in grains or lumps, and sometimes crystallized in six-sided prisms, whose sides are longitudinally channelled ‡.

Its colour is white. Its lustre metallic. Hardness 10. Brittle. Sp. gr. from 9.4406 § to 10.* Texture foliated. Fracture conchoidal. Before the blow-pipe the antimony evaporates in a grey smoke, and leaves a brownish slag, which tinges borax green. If borax be used at first, a silver bead may be obtained.

This alloy was long supposed to contain arsenic. Bergman examined it, and found only silver and antimony † His analysis has been confirmed by the experiments of Vauquelin and Selb ‡. According to Selb, it is composed of 89 silver,

11 antimony.

100

A specimen analysed by Klaproth, contained

84 silver,
16 antimony.

100

Another specimen contained

76 silver,
24 antimony.

100 ‡

† *Kirwan*, ii. 110.
‡ *Romé de Lisle*, iii. 461.
§ *Hauy, Jour. de Min.* N° xxx. p. 473.
* *Kirwan, ibid.*
† *Opusc.* ii. 415.
‡ *Jour. de Min. ibid*
‡ *Beiträge*, ii. 301.

GENUS II. SULPHURETS OF SILVER.

187 G. II. Sulphurets. Common sulphuret of silver.

SPECIES 1. Common sulphuret of silver *.

Vitreous silver ore.

This ore occurs in the silver mines of Germany and Hungary. It is sometimes in masses, sometimes in threads, and sometimes crystallized. Its crystals are either cubes or regular octohedrons, whose angles and edges are often variously truncated. For a description of the varieties produced by these truncatures, we refer the reader to *Romé de Lisle* †.

Its colour is dark bluish grey, inclining to black; often tarnished. Internal lustre metallic. Texture foliated. Fracture uneven. Hardness 4 to 5. May be cut with a knife like lead. Flexible and malleable. Sp. gr. 6.909 ‡ to 7.215 ‖ In a gentle heat the sulphur evaporates. Melts when heated to redness.

A specimen of this ore, analysed by Klaproth, contained

85 silver,
15 sulphur.

100 *

* *Kirwan*, ii. 115.
† *Crystal.* iii. 441.
‡ *Brisson.*
‖ *Gellert.*
* *Beiträge*, i. 162.

Metallic ores.

SPECIES 2. Antimoniated silver ore *.

Sulphuret of silver with antimony and iron.

188 Antimoniated silver ore. This ore, which occurs in Saxony and Hungary, seems to be sulphuret of silver contaminated with antimony and iron, and ought therefore, in all probability, to be considered merely as a variety of the last species. It is sometimes in masses, but more frequently crystallized in six-sided prisms, tables, or rhomboids; generally indistinct and accumulated together.

Its colour is iron grey; often tarnished. Its lustre metallic. Fracture uneven. Hardness 4 to 5. Brittle. Sp. gr. 7.208 †. Before the blow-pipe the sulphur and antimony exhale, leaving a bead, which may be freed from iron by fusion with nitre and borax.

A specimen of this ore, analysed by Klaproth, contained

66.5 silver,
12.0 sulphur,
10.0 antimony,
5.0 iron,
1.0 silica,
0.5 arsenic and copper.

95.0 ‡

* *Kirwan* ii. 118.
† *Gellert.*
‡ *Beiträge*, i. 166.

SPECIES 3. Sulphuret of silver and copper ‖

Cupriferous sulphurated silver ore.

189 Sulphuret of silver and copper. This ore, which is found in the Korbolokinsk mountains in Siberia, was first described by Mr Renovantz. It is in amorphous masses, varying in size from that of the thumb to that of the fist.

Its colour is bluish grey like lead. Lustre metallic. Hardness 5 to 6. Brittle. Its powder, when rubbed on the skin, gives it a black colour and a leaden gloss. Before the blow-pipe the sulphuret of silver melts readily; that of copper with difficulty. This ore is composed of about

42 silver,
21 copper,
35 sulphur.

98

‖ *Kirwan*, ii. 121.

GENUS III. OXIDES OF SILVER.

190 G. III. Oxides. Calciform silver ore.

SPECIES 1. Calciform silver ore *.

This ore was first described by Mr Widenman. It is sometimes in masses, sometimes disseminated through other minerals.

Its colour is greyish black. Its streak bright. Its lustre metallic. Its fracture uneven. Hardness 4 to 5. Brittle. Sp. gr. considerable. Effervesces with acids. Melts easily before the blow pipe. Froths with borax.

According to Selb, it contains 72.5 silver,

15.5 copper,
12.0 carbonic acid.

100.0

* *Kirwan*, ii. 112.

SPECIES 2. Red silver ore (u).

191 Red silver ore. This ore is very common in several German silver mines. It occurs in masses, disseminated and crystallized. The primitive form of its crystals is a dodecahedron ‡, whose sides are equal rhombs, and which may be con-

‡ Fig. 38.

(u) *Kirw.* II. 122.—*Scopoli de Minera Argenti, Rubra.*—*Sage, Jour. de Phys.* XXXIV. 331. *and* XLI. 370; and *Nouv. Jour. de Phys.* II. 284.—*Westrum, Jour. de Phys.* XLIII. 291.—*Klaproth, Beiträge*, I. 141.

Silver. considered as a six-sided rhomboidal prism, terminated by three-sided summits*. Sometimes the prism is lengthened, and sometimes its edges, or those of the terminating summits, or both, are wanting. For a description and figure of these varieties, we refer to *De Lisle* † and *Hauy* ‡.

* *Romé de Lisle*, iii. 447.
† *Ibid.*
‡ *Jour. d'Hist. Naturelle*, N° 18. p. 216.

Its colour is commonly red. Streak red. External lustre metallic, internal common. Transparency from 3 to 1; sometimes opaque. Fracture flat conchoidal. Hardness 5 to 7. Brittle. Sp. gr. from 5.44 || to 5.592 *. Becomes electric by friction, but only when insulated †. Soluble in nitric acid without effervescence ‡. Before the blow-pipe melts, blackens, burns with a blue flame, gives out a white smoke with a slight garlic smell, and leaves a silver bead ||.

|| *Kirwan.*
* *Vauquelin, Jour. de Min* N° xvii. p. 2.
† *Hauy, ibid.* N° xxx. p. 476.
‡ *Hauy, ibid.* N° xxxi. p. 518.
|| *Vauquelin, ibid.*

Variety 1. Light red.

Colour intermediate between blood and cochineal red; sometimes variegated. Streak orange red. Powder black.

Variety 2. Dark red.

Colour commonly between dark cochineal red and lead grey; sometimes nearly black, and without any shade of red. Streak dark crimson red.

This ore was long supposed to contain arsenic. Klaproth first ascertained its real composition *; and his analysis has been confirmed by Vauquelin, who found a specimen composed of 56.6748 silver,
16.1300 antimony,
15.0666 sulphur,
12.1286 oxygen.
———
100.

* *Ann. de Chim.* xviii 81.

Klaproth proved, that the silver and antimony are in the state of oxides; and Vauquelin, that the sulphur is combined partly with the oxide of silver and partly with the oxide of antimony. Klaproth obtained a little sulphuric acid; but this acid, as Vauquelin, with his usual ingenuity, demonstrated, was formed during the analysis.

This ore sometimes contains a minute portion of arsenic, but never more than .02 †.

† *Vauquelin, ibid.* p. 8.

192
G. IV. Salts. Muriat of silver.

Genus IV. salts of silver.

species 1. Muriat of silver (x).

Corneous silver ore.

This ore occurs at Johanngeorgenstadt in Saxony, in South America, &c. It is often amorphous, sometimes nearly in powder, and sometimes crystallized in cubes or parallelopipeds.

Its colours are various: when exposed to the light it becomes brown. Internal lustre greasy, 2; external, 2 to 1. Acquires a gloss when scraped with a knife. Transparency 2 to 1. Texture foliated. Hardness 4 to 5. Sp. gr. 4.745 ‡ to 4.804 ||. Before the blow-pipe it instantly melts, and gradually evaporates, but may be reduced by adding an alkali.

‡ *Briss n.*
|| *Gellert.*

Metallic ores.

That this ore contains muriatic acid, has been long known. Mr Woulfe first shewed that it contained also sulphuric acid *: and this discovery has been confirmed by Klaproth, according to whose analysis this ore is composed of 67.75 oxide of silver,
6.00 oxide of iron,
21.00 muriatic acid,
.25 sulphuric acid,
1.75 alumina.
———
96.75 †

* *Phil. Transf.* 1770.

The alumina can only be considered as mixed with the ore. Sometimes its quantity amounts to .67 of the whole ‡.

† *Beiträge*, i. 134.
‡ *Ibid.* p. 137.

Order III. ORES OF PLATINUM (y).

Hitherto no mine of platinum has been discovered. It is found in small scales or grains on the sands of the river Pinto, and near Carthagena in South America. It is always in a metallic state, and always combined with iron. 193 Mines.

Genus I. alloys of platinum.

species 1. Native platinum.

194
G. I. Alloys. Native platinum.

Its colour is whitish iron grey. Magnetic. Sp. gr. from 12 to 16. Soluble in nitro-muriatic and oxy-muriatic acids.

Order IV. ORES OF MERCURY.

Mercury is employed in medicine; it serves to separate silver and gold from their ores; the silvering of looking-glasses, gilding, &c. are performed by means of it; and its sulphuret forms a beautiful paint.

195 Mines.

Mercury abounds in Europe, particularly in Spain, Germany, and Hungary: it is found also in China (z), the Phillipines ||, and in Peru, and perhaps Chili (a) in South America. The most productive mines of mercury are those of Idria *; of Almaden, near Cordova in Spain, which were wrought by the Romans (b); of the Palatinate †; and of Guanca Velica in Peru (c).

|| *Carreri's Voyage.*
* *Scopoli,*
† *Jour. de Min.* N° xxxvi. p. 915.

Mercury has never been found in Britain, nor has any mine worth working been discovered in France. It occurs most commonly in argillaceous shistus, limestones, and sandstones.

Jour. de Min. N° vi. and vii.

Genus I. alloys of mercury.

species 1. Native mercury.

196.
G. I. Alloys. Native mercury.

Native mercury is found in most mercurial mines: it is in small globules, scattered through different kinds of stones, clays, and ores.

Fluid. Colour white. Sp. gr. about 13.6.

(x) *Kirw.* II. 113.—*Laxman. Nov. Comm. Petropol.* XIX. 482.—*Monnet, Mem. Sçav. Etang.* IX. 717.

(y) See *Brownrigg, Phil. Transf.* XLVI. 584.—*Lewis, ibid.* XLVIII. 638. and L. 148.—*Margraf, Mem. Berlin*, 1757, p. 314.—*Macquer, Mem. Par.* 1758, p. 119.—*Buffon, Jour. de Phys.* III. 324.—*Morveau, ibid.* VI. 193.—*Bergman, Opusc.* II. 166.—*Tillet, Mem. Par.* 1779, p. 373, and 385, and 545.—*Crell, Crell's Annals*, 1784. 1 *Band.* 328.—*Willis, Manchester Memoirs*, III. 467.—*Mussin Puschkin, Ann. de Chim.* XXIV. 205.—*Morveau, ibid.* XXV. 3.

(z) See *Entrecolle's Lettres Edificantes.*

(a) See *Molina's Natural History of Chili.*

(b) See *Bowle's Natural History of Spain*, and *Jour. de Min.* N° xxxi. p. 555.

(c) See *Ulloa's Memoirs concerning America.*

Ores of Mercury.

SPECIES 2. Amalgam of silver *.

Native amalgam.

197 Amalgam of silver. This mineral has been found in the silver mine of Sahlberg †, in the province of Dalecarlia, in Sweden; in the mines of Deux Ponts ‡, in the Palatinate; and in other places. It is in thin plates, or grains, or crystallized in cubes, parallelopipeds, or pyramids.

Its colour is silvery white or grey. Lustre metallic. Creaks when cut. Sp. gr. above 10. Tinges gold white. Before the blow-pipe the mercury evaporates and leaves the silver.

A specimen of this amalgam, analysed by Klaproth, contained

64	mercury,
36	silver.
100 §	

Sometimes it contains a mixture of alumina, and sometimes the proportion of mercury is so great that the amalgam is nearly as soft as paste.

* Kirwan, ii. 223.
† Cronstedt's Min.
‡ Heyer, Crell's Annals, 1790.
§ Beiträge, i. 183.

198 G. II. Sulphurets Common sulphuret.

GENUS II. SULPHURETS OF MERCURY.

SPECIES 1. Common sulphuret ||.

Native cinnabar.

This ore, which is found in almost all mercurial mines, is sometimes in veins, sometimes disseminated, sometimes in grains, and sometimes crystallized. The form of its crystals is a tetrahedron or three-sided pyramid, most commonly wanting the summit; sometimes two of these pyramids are joined base to base; and sometimes there is a three sided prism interposed between them ¶.

Its colour is red. Its streak red and metallic. Lustre when crystallized 2 to 3; when amorphous, often c. Transparency, when crystallized, from 1 to 3; when amorphous, often 0. Texture generally foliated. Hardness from 3 to 8. Sp. gr. from 5.419 to 10.1285.

Before the blow-pipe evaporates with a blue flame and sulphureous smell. Insoluble in nitric acid *.

Variety 1. Dark red.

Colour cochineal red. Hardness 6 to 7. Sp. gr. when pure, 10.1285 †; sometimes only 7.2, or even 6.188 ‡.

Variety 2. Bright red.

Colour commonly scarlet. Sp. gr. 6.9022 § to 5.419 ||.

|| Kirwan, ii. 228.
¶ Romé de Lisle, iii. 154.
* Hauy, Jour. de Min. N° xxxi. p. 518.
† Brisson.
‡ Muschenbroek.
§ Brisson.
|| Gellert.

199 G. III. Oxides. Hepatic mercurial ore.

GENUS III. OXIDES OF MERCURY.

SPECIES 1. Hepatic mercurial ore ¶.

This ore, which is the most common in the mines of Idria, is always amorphous, and is often mixed with native mercury and cinnabar.

Its colour is somewhat red. Its streak dark red and brighter. Lustre commonly metallic. Hardness from 6 to 8. Sp. gr. from 9.2301 * to 7.186 †. When heated the mercury evaporates.

Though this ore has never been accurately analysed, chemists have concluded that the mercury which it contains is in the state of a red oxide, because it is insoluble in nitric and soluble in muriatic acid ‡. When purest, it contains about .77 of mercury §. It contains also some sulphur and iron.

Werner has divided this species into two varieties, the *compact* and the *slaty*. The second is often nothing more than bituminous shale impregnated with oxide of mercury ||.

¶ Kirwan, ii. 224.
* Brisson.
† Kirwan.
‡ Sage, Jour. de Phys. xxiv. 61.
§ Scopoli, Jour. de Min. N° xxxvi. p. 919.
|| Kirwan, ii. 226.

GENUS IV. MERCURIAL SALTS.

SPECIES 1. Muriat of mercury *.

Corneous mercury.

Metallic Ores.

200 Mercurial Salts. Muriat of mercury. This ore, which occurs in the Palatinate, is sometimes in scales, sometimes in grains, and sometimes crystallized. Its crystals are either small four or six sided prisms whose sides are rhombs †, or cubes, or four-sided pyramids wanting their angles. They are always very small and generally confused.

Its colours are various; but it is most frequently white. Its lustre, when white, is pearly. Sometimes opaque, and sometimes semitransparent. Evaporates before the blow-pipe.

Mr Woulfe discovered that this ore generally contains some sulphuric acid ‡. Specimens have been found in which the quantity of sulphuric acid exceeds that of the muriatic §.

* Kirwan, ii. 226.
† Romé de Lisle, iii. 161.
‡ Phil. Trans. lxvi. 618.
§ Suckow.

ORDER V. COPPER ORES.

MANY of the most useful utensils are formed of copper: it enters largely into the composition of brass, bronze, and bell metal; not to mention the dyes and paints of which it is the basis.

201 Mines. Copper mines abound in most countries. They are wrought in China, Japan, Sumatra; the north of Africa; in Chili and Mexico; and in most parts of Europe; especially Britain, Germany, Russia, Hungary.

Copper is found most commonly in rocks of hornblende, shistus, and quartz.

202 G. I. Alloys. Native copper.

GENUS I. ALLOYS OF COPPER.

SPECIES 1. Native copper ||.

Native copper occurs now and then in the greater number of copper mines: Sometimes it is in masses, sometimes in plates and threads, which assume a variety of forms; and sometimes, as in Siberia, it is crystallized in cubes, or other forms nearly resembling cubes §.

Colour commonly that of copper, but sometimes dark brown. Lustre metallic. Streak brighter. Fracture hackly. Flexible and malleable. Hardness 6 to 7. Sp. gr. from 7.6 * to 8.5844 †.

|| Kirwan, ii. 127.—Cartheuser.
§ Hauy, Jour. de Min. N° xxxi. 509.
* Kirwan, Min. ii. 128.
† Hauy, ibid. p. 509.

SPECIES 2. White copper ore ‡.

Alloy of copper, iron, and arsenic.

203 White copper ore. This ore, which is said to be uncommon, occurs in masses. Colour white. Lustre metallic. Fracture uneven. Hardness 8 to 9. Brittle. Sp. gr. considerable.

Before the blow-pipe gives out a white arsenical smoke, and melts into a greyish black slag §.

‡ Kir. Min. ii. 152.
§ Widenman.

204 G. II. Sulphurets. Copper. Common sulphuret of copper.

GENUS II. SULPHURETS OF COPPER.

SPECIES 1. Common sulphuret of copper ||.

Vitreous copper ore.

This ore, which is found in Cornwall, Hungary, and Siberia, occurs in masses, plates, threads, and crystallized in six-sided prisms, or four-sided pyramids, joined base to base.

Colour bluish grey. Streak brighter grey. Lustre metallic. Hardness 4 to 7. Sp. gr. 5.452 ¶ to 5.565 *; sometimes so low as 4.129 †. Detonates with nitre.

Before the blow-pipe it melts easily; and while the fusion exhibits a green pearl, which, on cooling, is covered with a brown crust. Tinges borax green.

Werner makes two varieties of this ore: the first he calls

|| Kirwan, ii. 144.
¶ Kirwan.
* Gellert.
† Kirwan.

Copper Ores.

calls *compact*, from its fracture; and the second, for the same reason, he calls *foliated*. This last is somewhat darker coloured than the first, but in other respects they agree.

205 Copper pyrites. * Kirwan, ii. 140.

SPECIES 2. Copper pyrites *.

Yellow copper ore.

This ore, which is probably nothing else than sulphuret of iron combined with copper, and which, therefore, would be more properly placed among iron ores, is found frequently in copper mines, and mixed with common pyrites or sulphuret of iron. It is sometimes amorphous, and sometimes crystallized. Its crystals are either three or four sided pyramids applied base to base, or six-sided plates.

Its colour is yellow; often tarnished. Its internal lustre metallic. Hardness 6 to 7; sometimes 9. Brittle. Sp. gr. 4.314 † to 4.08 ‡. Deflagrates; but does not detonate with nitre §.

† *Brisson.* ‡ *Kirwan,* § *Id. Min.* ii. 141.

Before the blow-pipe decrepitates, gives a greenish sulphureous smoke, and melts into a black mass, which tinges borax green. Does not effervesce with nitric acid.

206 Purple copper ore. || Kirwan, ii. 142.

SPECIES 3. Purple copper ore ||.

This ore is found in masses, or plates, or disseminated; sometimes, also, it is crystallized in octahedrons. Colour various, but most commonly purple; internally reddish. Streak reddish and bright. Lustre metallic. Hardness 6 to 7. Brittle. Sp. gr. 4.956 to 4.983 ¶.

¶ *Ibid.* ii. 143.

Effervesces with nitric acid, and tinges it green. Deflagrates with nitre. Before the blow-pipe melts readily, without smoke, vapour, or smell; but is not reduced. Tinges borax a bright green.

A specimen of this ore, analysed by Klaproth, contained

58 copper,
18 iron,
19 sulphur,
5 oxygen.
———
100 †

† *Beiträge,* ii. 286.

207 Grey copper ore. ‡ Kirwan, ii. 146.

SPECIES 4. Grey copper ore ‡.

This ore is found in Cornwall, Saxony, Hungary, &c. It is often amorphous, but often also crystallized. The primitive form of its crystals is the regular tetrahedron; but, in general, either the angles or the edges, or both, are truncated or bevelled §.

§ *Romé de Lisle,* iii. 345.

Colour steel grey; often tarnished, and then dark grey. Streak dark grey; sometimes reddish brown. Powder blackish; sometimes with a tint of red. Lustre metallic. Hardness 7 or 8. Very brittle. Sp. gr. 4.8648 ||. Deflagrates with nitre. Before the blow-pipe crackles, but at last melts, especially if assisted by borax. The bead gives a white smoke, without any particular smell; tinges borax yellow or brownish red, but does not unite with it.

|| *Hauy. Jour. de Min.* N° xxxi. 512.

A specimen of this ore from Cremnitz, analysed by Klaproth, contained

31 copper,
14 silver,
34 antimony,
3 iron,
11 sulphur.
—
93

Napion, in an ore from the valley of Lanzo, found copper, silver, and antimony, nearly in the same proportions, but more iron, and some arsenic *. Savoresi, as Baron Born informs us, besides the ingredients of Klaproth's analysis, found some gold and mercury in grey copper ore †: and Klaproth himself found lead in most of the other specimens which he examined.

Metallic Ores.

* *Mem. Turin,* v. 173. † *Catal.* ii. 498.

208 G. III. Oxides. Red oxide of copper. ‡ Kirwan, ii. 135.

GENUS III. OXIDES OF COPPER.

SPECIES 1. Red oxide of copper ‡.

Florid red copper ore—Red copper glass.

This ore is found in Cornwall, and many other countries. It occurs in masses, disseminated, in scales, and crystallized. The figure of its crystals is most commonly the octahedron §.

§ *Hauy, Jour. de Min.* N° xxxi. 517.

Colour commonly cochineal red. Streak brick red. Lustre semimetallic. Transparency, when amorphous, generally 0; when crystallized, 3 or 4. Hardness from 4 to 7. Soluble with effervescence in nitric acid. Before the blow-pipe melts easily, and is reduced.

This ore was supposed to be composed of carbonic acid and red oxide of copper; but a specimen, examined by Vauquelin, which consisted of pure crystals, contained no acid ||. It must therefore be considered as an oxide of copper.

|| *Ibid.*

Werner has made three varieties of this ore, which, from their texture, he has denominated *compact*, *foliated*, and *fibrous*. The first is seldom or never found crystallized, and is opaque; the second occurs amorphous, crystallized, and in scales; the third is carmine, ruby, or scarlet red; and occurs always in short capillary crystals, or delicate flakes.

This ore sometimes contains a mixture of red oxide of iron; it is then called *brick red copper ore*, *copper malm*, or *copper ochre*.

This ore is sometimes mixed with bitumen. Its colour is then brownish black, and it is called *pitch ore*.

209 Green oxide of copper. * Kirwan, ii. 149.

SPECIES 3. Green oxide of copper *.

Green sand of Peru.

This ore, which was brought from Peru by Dombey, is a grass green powder, mixed with grains of quartz. When thrown on burning coals, it communicates a green colour to the flame. It is soluble both in nitric and muriatic acids without effervescence. The solution is green. It was supposed to contain muriatic acid †; but Vauquelin has discovered that the appearance of this acid was owing to the presence of some common salt, which is accidently mixed with the sand ‡.

† *Berthollet, Mem. Par.* 1786, 462. ‡ *Jour. de Min.* N° xxxi. 519.

210 G. IV. Salts. Blue carbonat of copper.

GENUS IV. SALTS OF COPPER.

SPECIES 1. Blue carbonat of copper (D).

Mountain blue—Azure de cuivre—Blue calx of copper—Kupfer lazur.

This ore, which occurs in the copper mines of Siberia, Sweden, Germany, Hungary, Cornwal, &c. is either amorphous or crystallized. The crystals are small, and difficult to examine. According to Romé de Lisle, their primitive form is an octahedron, the sides of which are isosceles triangles, and two of them more inclined than the others §. Be that as it may, the crystals of blue carbonat of copper are often rhomboidal prisms, either regular, or terminated by dihedral summits ||.

§ *Crystal.* iii. 343. || *Ibid.* p. 345.

Its colour is azure or smalt blue. Streak blue. Hardness

(D) *Kirwn.* II. 129.—*Morveau, Mem. Dijon,* 1782. 1 *Semestre,* p. 100.

Copper Ores. nefs 4 to 6. Brittle. Sp. gr. 3.608 ‡. It effervefces with nitric acid, and gives it a blue colour. Before the blow-pipe it blackens, but does not melt. Tinges borax green with effervefcence.

‡ Briffon.

The cryftals, according to Pelletier, are compofed of

66 to 70 copper,
18 — 20 carbonic acid,
8 — 10 oxygen,
2 — 2 water.

Fontana firft difcovered that this ore contained carbonic acid gas.

Variety 1. Earthy blue carbonat.

Mountain blue.

This variety generally contains a mixture of lime. It is never cryftallized; and fometimes is almoft in the ftate of powder. Luftre 0. Texture earthy.

Variety 2. Striated blue carbonat of copper.

Luftre glaffy. Tranfparency, when cryftallized, 2; when amorphous, 1. Texture ftriated; fometimes approaching to the foliated.

211 Green carbonat of copper.

SPECIES 2. Green carbonat of copper (E).

Oxygenated carbonat of copper—Malachite.

This ore is generally amorphous, but fometimes it is cryftallized in four-fided prifms, terminated by four-fided pyramids.

Colour green. Luftre filky. Hardnefs 5 to 7. Brittle. Sp. gr. 3.571 * to 3.653 ‡. Effervefces with nitric acid, and gives a blue colour to ammonia. Before the blow-pipe it decrepitates and blackens, but does not melt. Tinges borax yellowifh green. It is compofed of carbonic acid and green oxide of iron.

* Briffon. ‡ Kirwan.

Variety 1. Fibrous malachite.

Texture fibrous. Opaque when amorphous; when cryftallized its tranfparency is 2. Colour generally grafs green.

Variety 2. Compact malachite.

Texture compact. Opaque. Colour varies from the dark emerald green to blackifh green.

A fpecimen of malachite from Siberia, analyfed by Klaproth, contained

58.0 copper,
18.0 carbonic acid,
12.5 oxygen,
11.5 water.
———
100 *

* Beiträge, ii. 290.

This fpecies is fometimes mixed with clay, chalk, and gypfum, in various proportions; it is then known by the name of

Common mountain green.

Its colour is verdigris green. Luftre 0. Tranfparency 0 to 1. Hardnefs 3 to 4. Brittle. Texture earthy. Effervefces feebly with acids. Before the blow-pipe it exhibits the fame phenomena with malachite.

212 Sulphat of copper.

SPECIES 3. Sulphat of copper.

For a defcription of this falt, fee CHEMISTRY, n° 648. in this *Supplement.*

213 Arfeniat of copper.

SPECIES 4. Arfeniat of copper ‡.

Olive copper ore.

This ore is found at Cararach in Cornwal. It is generally cryftallized in fix-fided compreffed prifms. Its colour is olive green. Streak fometimes ftraw coloured, fometimes olive green. Luftre glaffy. Tranfparency from 4 to 2. Fracture conchoidal. Hardnefs 4 to 7. Before the blow-pipe deflagrates with an arfenical fmoke, and melts into a grey coloured bead. This bead, fufed with borax, leaves a button of pure copper ||.

‡ Kirwan, ii. 151.

Metallic Ores.

Klaproth difcovered that it was compofed of oxide of copper and arfenic acid.

|| Klaproth's Obfervations on Cornwal, p. 29.

Sometimes this ore is combined with iron. It then cryftallizes in cubes. Thefe cubes are of a dark green colour; before the blow-pipe they frothe, give out an arfenical fmoke, and do not fo quickly form a grey bead as the arfeniat of copper *.

* Ibid. p. 29.

ORDER VI. IRON ORES.

214. Mines.

To defcribe the ufes of iron, would be to write the hiftory of every art and manufacture, fince there is not one which is not more or lefs dependent upon this ufeful metal. Nor is its abundance inferior to its utility. It exifts almoft everywhere, and feems, as it were, the bond which connects the mineral kingdom together.

215 G. I. Alloys. Native iron.

GENUS I. ALLOYS OF IRON.

SPECIES 1. Native iron (F).

Native iron has been found in Siberia and in Peru in immenfe maffes, which feemed as if they had been fufed. Thefe maffes evidently did not originate in the place where they were found. See *Fire-balls, Suppl.*

Colour bluifh white. Fracture hackly. Luftre metallic. Malleable. Magnetic. Hardnefs 8 to 9. Sp. gr. 7.8. Prouft has difcovered, that the native iron found in Peru is alloyed with nickel ¶.

¶ Nicholfon's Jour. iii. 374.

216. G. III. Sulphurets. Common fulphuret of iron.

GENUS II. SULPHURETS OF IRON.

SPECIES 1. Common fulphuret of iron *.

Pyrites.

This mineral occurs very frequently both in ores and mixed with other bodies, for inftance in flates. It is often amorphous, and often alfo cryftallized. The primitive form of its cryftals is either a regular cube or an octohedron. The varieties of its form hitherto defcribed amount to 30; for a defcription of which we refer the reader to *Romé de Lifle* †.

* Kirwan, ii. 76.—Henkel's Pyritologia.

† Cryftal. iii. 208.

Its colour is yellow. Its luftre metallic. Hardnefs 8 to 10. Brittle. Sp. gr. 3.44 to 4.6. Soluble in nitric acid with effervefcence. Scarce foluble in fulphuric acid. Before the blow-pipe burns with a blue flame and a fulphureous fmell, and leaves a brownifh bead, which tinges borax of a fmutty green.

Variety 1. Common pyrites.

Fracture uneven. Hardnefs 10. Decrepitates when heated. Emits a fulphureous fmell when rubbed. Not magnetic. It occurs often in coal mines and in flates.

Variety 2. Striated Pyrites.

Texture ftriated. Hardnefs 10. Not magnetic.

Variety 3. Capillary.

Colour often fteel grey. Found in needle-form cryftals. Uncommon. Not magnetic.

Variety 4. Magnetic pyrites.

Found in maffes. Texture compact. Hardnefs 8, 9. Slightly magnetic. Seems to contain lefs fulphur than the other varieties.

In pyrites the proportion of the fulphur to the iron is variable; and this explains the variety of its cryftalline forms.

GENUS

(E) *Kirw.* II. 131.—*Fontana, Jour. de Phyf.* XI. 509.—*Klaproth, Beiträge,* II. 287.
(F) *Pallas, Phil. Tranf.* LXVI. 523.—*Rubin de Celis, ibid.* LXVIII. 37.—See alfo *Schreiber, Jour. de Phyf.* XLI. 3.; and *Stelin, Phil. Tranf.* LXIV. 461.

Iron Ore. Metallic Ores.

GENUS III. CARBURET OF IRON.

SPECIES 1. Plumbago *.

Graphite of Werner.

217 G. III. Plumbago.

This mineral is found in England, Germany, France, Spain, America, &c. It occurs in kidney-form lumps of various sizes. Its colour is dark iron grey or brownish black; when cut, bluish grey. Lustre metallic, from 3 to 4. Opaque. Structure slaty. Texture fine grained. Hardness 4 to 5. Brittle. Sp. gr. from 1.987 to 2.089; after being soaked in water 2.15; after being heated 2.3, and when heated after that 2.41 †. Feels somewhat greasy. Stains the fingers, and marks strongly. The use of this mineral when manufactured into pencils is known to every person.

Its composition was discovered by Scheele. When pure it contains

90	carbon,
10	iron.
100	

But it is often exceedingly impure: A specimen, for instance, from the mine of Pluffier, in France, analysed by Vauquelin, contained

23	carbon,
2	iron,
38	silica,
37	alumina.
100 ‡	

218. G. IV. Emery.

GENUS IV. IRON COMBINED WITH SILICA.

SPECIES 1. Emery *.

This mineral is commonly disseminated through other fossils, but sometimes in the East Indies it occurs in large masses.

Its colour is bluish grey, greyish brown, or bluish black, often covered with a yellowish rind; internally it discovers red or purple spots. Lustre 1 or 0; in some parts 2, and metallic. Opaque. Hardness 14. Brittle. Sp. gr. 3.92 †. Before the blow-pipe it blackens and gives a smutty yellow tinge to borax.

According to Wiegleb it contains

95.6	silica,
4.3	iron.
99.9	

219 G. V. Oxides.

GENUS V. OXIDES OF IRON.

This genus is very extensive; for iron is much more frequently found in the state of an oxide than in any other.

220 Black oxide of iron.

SPECIES 1. Black oxide of iron ‡.

Common magnetic iron stone—Blackish octohedral iron ore.

This species of ore is very common in Sweden; it is found also in Switzerland, Norway, Russia, &c. It occurs in masses, plates, grains, and crystallized. The primitive form of its crystals is a regular octohedron †. Sometimes two opposite sides of the pyramids are trapeziums, which renders the apex of the pyramids cuneiform. Sometimes the crystals pass into rhomboidal parallelopipeds, and into dodecahedrons with rhomboidal faces §.

Its surface is brownish black; internally bluish grey. Powder black *. Streak blackish grey, brighter. Lustre metallic. Hardness 9 to 10. Brittle. Sp. gr. from 4.094 to 4.688 †. Attracted by the magnet, and generally possessed of more or less magnetic virtue ‡. To this species belongs the magnet. Before the blow-pipe it becomes browner, but does not melt. Tinges borax dark green.

When pure it consists entirely of oxide of iron; and this oxide appears to contain from .15 to .24 oxygen, and from .76 to .85 iron §. Undoubtedly it consists of a mixture of iron in two different states of oxidation. It is often also mixed and contaminated with foreign ingredients.

There are two varieties of this ore. The first is what we have just described; the second is in the form of sand, and has therefore been called

Magnetic sand *.

This substance is found in Italy, Virginia, St. Domingo, the East Indies, and in the sand of the river Don at Aberdeen in Scotland. It is black, very hard, magnetic. Sp. gr. about 4.6 Not altered by the blowpipe *per se*; melts into a black glass with potass, and into a green glass with microcosmic salt, both opaque †. It probably contains some silica, as Kirwan has supposed ‡.

221 Specular iron ore.

SPECIES 2. Specular iron ore ¶.

Fer oligiste.

This ore is found abundantly in the isle of Elba near Tuscany. It is either in masses or crystallized. The primitive form of its crystals, and of its integrant molecules, is the cube *. The varieties hitherto observed amount to 7. These are the rhomboidal parallelopiped; the cube, with three triangular faces instead of two of its angles diagonally opposite; two six-sided pyramids, applied base to base, wanting the summits ‡, and sometimes the angles at the bases, and sometimes the alternate edges of the pyramid; a polyhedron of 24 sides, resembling a cube with three triangular faces for two angles diagonally opposite, and two triangles for the rest of its angles. For a description and figure of these varieties, we refer to *Romé de Lisle* † and *Hauy* ‡.

Colour steel grey; often tarnished, and beautifully iridescent, reflecting yellow, blue, red. Streak red. Powder dark red. Lustre metallic. Hardness 9 to 10. Not brittle. Sp. gr. 5.0116 † to 5.218 ‡. Slightly magnetic. Little altered by the blow-pipe. Tinges borax an obscure yellow.

This ore, according to Mr Mushet, is composed of

66.1	iron,
21.2	oxygen,
10.7	water and carbonic acid,
2.0	lime.
100.0 †	

The quantity of oxygen here stated is probably too small, owing to the unavoidable inaccuracy which results from the *dry way* of analysis which Mr Mushet followed.

Micaceous iron ore

Is generally considered as a variety of this species. Kirwan, however, supposes it to contain carbon, and to be a distinct species.

It is found in Saxony, and in the isle of Elba, &c. generally in amorphous masses, composed of thin six-sided laminæ. Colour iron grey. Streak bluish grey. Lustre metallic. Opaque. Feels greesy. Hardness 5 to 7. Brittle, Sp. gr. from 4.5 to 5.07. Slightly magnetic.

* Kirwan, ii. 58.
† Brisson.
‡ Jour. de Min. N° xii. p. 16.
* Kirwan, ii. 193.
† Brisson.
‡ Kirwan, ii. 158.
† Romé de Lisle, iii. 178.
§ Ibid.
* Hauy, Jour. de Min. N° xxxiii. 659.
† Kirwan's Min. ii. 159.
‡ Hauy, Jour. de Min. N° xxxi. 527.
§ Kirwan. Min. ii. 159.
* Kirwan, ii.—Dupuget, Jour. de Min. N° xxi. p. 75.
† Fourcroy, Ann. de Chim. ii. 127.
‡ Min. ii. 161.
¶ Kirw. ii. 162.—Coudrai, Jour. de Phys. iv. 52.
* Hauy, Jour. de Min. N° xxxiii. 660.
‡ Fig. 39.
† Cryst. iii. 189.
‡ Ibid. 660.
† Hauy,
‡ Brisson.
† Philos. Mag. iii. 354.

Iron Ores. magnetic. Infufible by the blow-pipe. Tinges borax greenifh brown.

212 Laminated fpecular iron ore.

SPECIES 3. Laminated fpecular iron ore.

Fer pyrocoti of Hauy.

This ore, which is found at Montd'or in Auvergn, was ufually arranged under the laft fpecies; but has been feparated from it, we think properly, by Mr Hauy, becaufe the form of its cryftals is incompatible with the fuppofition that their primitive nucleus is a cube, as we have feen is the cafe with common fpecular iron ore. Its cryftals are thin octagonal plates, bounded by fix linear trapeziums, alternately inclined different ways *.

Colour fteel grey. Powder reddifh black. Luftre metallic; furface polifhed. Fracture glaffy. Very brittle †. Hauy fuppofes that this ore has been produced by fire, and accordingly has given it a name which denotes its origin.

* De Lifle, iii. 188.

† Hauy, Jour. de Min. N° xxxi. 33.

223 Brown iron ore.

SPECIES 4. Brown iron ore ‡.

This fpecies of ore is found abundantly in Britain, particularly in Cumberland and Lancafhire; and it is alfo very common in other counties. It confifts of the brown oxide of iron, more or lefs contaminated with other ingredients.

‡ Kirw. ii. 163.

Its colour is brown. Its ftreak reddifh brown. Sp. gr. from 3.4771 to 3.951. Before the blow-pipe blackens, but does not melt. Tinges borax greenifh yellow.

Variety 1. Brown hæmatites.

The name hæmatites (bloodftone) was probably applied by the ancients only to thofe ores which are of a red colour, and have fome refemblance to clotted blood; but by the moderns it is applied to all the ores of iron which give a reddifh coloured powder, provided they be of a fibrous texture.

Brown hæmatites occurs in maffes of various fhapes, and it is faid alfo to have been found cryftallized in five or fix fided acute angled pyramids. Colour of the furface brown or black, fometimes iridefcent; internally nut brown. Powder red. Texture fibrous. Hardnefs 8 to 10. Brittle. Sp. gr. 3.789 § to 3.951 ‖. Not magnetic.

§ Gellert.

‖ Kirwan.

This variety has not been analyfed, but it feems to confift of brown oxide of iron, oxide of manganefe, and alumina ¶.

¶ Kirwan's Min. ii. 164.

Variety 2. Compact brown iron ftone.

This variety occurs in maffes of very various and often fantaftical fhapes.

Colour brown. Internal luftre metallic. Texture compact. Hardnefs 6 to 9. Brittle. Sp. gr. 3.4771 * to 3.551 †.

* Briffon.

† Kirwan.

Variety 3. Brown fcaly iron ore.

This variety is generally incumbent on other minerals. Colour brown. Luftre metallic. Stains the fingers, marks ftrongly. Feels unctuous. Texture foliated. Hardnefs 3 to 5. Brittle. So light as often to float on water.

Variety 4. Brown iron ochre.

This variety occurs both maffive and diffeminated. Colour from nut brown to orange. Luftre 0. Strongly ftains the fingers. Texture earthy. Hardnefs 3 to 4. When flightly heated reddens.

224 Red iron ore.

SPECIES 5. Red iron ore ‡.

‡ Kirw. ii. 168.

Colour red. Streak blood red. Sp. gr. from 3.423 to 5.005. Before the blow-pipe blackens, but does not melt. Tinges borax yellowifh olive green. When digefted in ammonia, it becomes black and often magnetic.

Variety 1. Red hæmatites.

Found in maffes, and all the variety of forms of ftalactites. Colour between brownifh red and fteel grey. Powder red. Internal luftre metallic. Texture fibrous. Hardnefs 9 to 10. Brittle. Sp. gr. 4.74 * to 5.005 †.

When pure it confifts of red oxide of iron, but it often contains manganefe and alumina ‡.

* Gellert.

† Kirwan.

‡ Kirwan's Min. ii. 169.

Variety 2. Compact red iron ore.

Found maffive and ftalactitic; fometimes in cryftals of various forms, but they feem to be only fecondary; fometimes in columns like bafalt.

Colour between brown red and fteel grey. Stains the fingers. Luftre 1 to 0; often femimetallic. Texture compact. Hardnefs 7 to 9. Brittle. Sp. gr. 3.423 to 3.76 §. Sometimes invefted with a rofy red ochre.

§ Kirwan.

Variety 3. Red ochre.

Found fometimes in powder, fometimes indurated. Colour blood red. Stains the fingers. Luftre 0. Texture earthy. Hardnefs 3 to 5. Brittle.

Variety 4. Red fcaly iron ore.

This variety is generally found incumbent upon other iron ores. Colour between cherry red and fteel grey. Stains the fingers. Luftre filky, inclining to metallic. Texture foliated. Feels unctuous. Hardnefs 3 to 4. Brittle. Heavy.

225 Argillaceous iron ore.

SPECIES 6. Argillaceous iron ore ‖.

Oxid of iron combined or mixed with clay.

This ore is exceedingly common; and though it contains lefs iron than the fpecies already defcribed, it is, in this country at leaft, preferred to them, becaufe the method of extracting pure iron from it is eafier, or rather becaufe it is better underftood.

‖ Kirw. ii. 173.

Colour moft commonly dark brown. Streak red or yellowifh brown. Sp. gr. from 2.673 to 3.471 *. Before the blow-pipe blackens, and tinges borax olive green and blackifh. It is compofed of oxide of iron, alumina, lime, filica in various proportions. It generally yields from 30 to 40 *per cent.* of iron.

* Kirwan.

Variety 1. Common argillaceous iron ore.

The minerals arranged under this variety differ confiderably from each other in their external characters. They are found in maffes of various fhapes, and often form large ftrata.

Colour various fhades of grey, brown, yellow, and red. Streak reddifh yellow or dark red. Luftre 0. Hardnefs from 3 to 8. Smell earthy when breathed upon.

Variety 2. Columnar or fcapiform iron ore.

This variety is found in columns, adhering to each other, but eafily feparable: They are commonly incurvated, and their furface is rough. Colour brownifh red. Streak dark red. Slightly ftains the fingers. Luftre 0. Adheres ftrongly to the tongue. Sound hollow. Feel dry. Texture earthy.

Variety 3. Acinofe iron ore.

This variety is found in maffes, and is commonly lenticular. Colour generally brownifh red. Luftre metallic, nearly. Texture granular. Hardnefs 5 to 9. Brittle.

Variety

Iron Ores.

Variety 4. Nodular, or kidney-form iron ore.

Ætites or *Eagleſtone*.

This variety, which was mentioned by the ancients, is generally found under the form of a rounded knob, more or leſs reſembling a kidney, though ſometimes it is quadrangular; and it contains within it a kernel, which is ſometimes looſe, and ſometimes adheres to the outſide rind. Colour of the ſtone yellowiſh brown; of the kernel ochre yellow. Surface generally fouled with earth. Luſtre of the rind metallic; of the kernel 0. Hardneſs from 4 to 7. Brittle.

Variety 5. Piſiform or granular iron ore.

This variety occurs in rounded maſſes, from the ſize of a pea to that of a nut. Surface rough. Colour commonly dark brown. Streak yellowiſh brown. Hardneſs 5 to 6. Brittle.

The oolitic ore found at Creuſot, near mount Cenis, belongs to this variety. It is compoſed of

50	lime,
30	iron,
20	alumina.
100	

226 Lowland iron ore.

SPECIES 7. Lowland iron ore *.

This ſpecies of ore is ſuppoſed to conſiſt of oxide of iron, mixed with clay and phoſphuret or phoſphat of iron. It is called lowland ore, becauſe it is found only in low grounds; whereas the laſt ſpecies is more commonly in high grounds; and is therefore cally *highland ore*.

* Kirw. ii. 179.

This ore occurs in amorphous maſſes, and alſo in grains or powder. Its colour is brown. Streak yellowiſh brown. Luſtre 0, or common. Texture earthy. Hardneſs 3 to 5.

Variety 1. Meadow lowland ore.

Colour blackiſh or yellowiſh brown: Both colours often meet in the ſame ſpecimen. Found in lumps of various ſizes, often perforated. Fracture compact. Moderately heavy.

Frequently yields from 32 to 38 *per cent.* of iron.

Variety 2. Swampy iron ore.

This variety is generally found under water. It is in lumps, which are commonly perforated or corroded, and mixed with ſand. Colour dark yellowiſh brown, or dark nut brown. Hardneſs 3 to 4. Brittle. Sp. gr. 2.944. It often contains .36 of iron.

Variety 3. Moraſſy iron ore.

This variety is found either in a looſe form or in perforated lumps. Colour light yellowiſh brown. Stains the fingers. Hardneſs 3. Friable.

227 G. VI. Salts. Sparry iron ore.

GENUS VI. SALTS OF IRON.

SPECIES 1. Sparry iron ore (G).

This ore is common in Germany, France, and Spain. It is found ſometimes in amorphous maſſes, and ſometimes cryſtallized.

Its colour is white; but it becomes tarniſhed by expoſure to the air, and then aſſumes various colours. Streak grey or white. External luſtre often metallic; internal common or glaſſy. Tranſparency 1 or 2; ſometimes 0. Texture foliated. Fragments rhomboidal. Hardneſs 5 to 7. Brittle. Sp. gr. 3.6 to 3.810. Not magnetic. Soluble in acids with very little efferveſcence. Before the blow-pipe decrepitates, becomes browniſh black, and magnetic; but is ſcarcely fuſible. Tinges borax ſmutty yellow, with ſome efferveſcence.

This ore, as Bergman aſcertained, conſiſts of iron, mangaueſe, lime, and carbonic acid.

One ſpecimen, according to his analyſis, contained

38	iron,
24	mangaueſe,
38	carbonat of lime.
100	

Another contained

22	iron,
28	manganeſe,
50	carbonat of lime.
100	

Whether the iron be combined with the carbonic acid is ſtill a diſputed point. The cryſtals of this ore are rhomboidal parallelopipeds; which is preciſely the form of carbonat of lime. This amounts nearly to a demonſtration, that the carbonic acid is combined with the lime; and that, as Cronſtedt and Hauy have ſuppoſed, this ore is merely carbonat of lime, contaminated with a quantity of the oxids of iron and manganeſe.

228 Arſeniat of iron.

SPECIES 2. Arſeniat of iron.

Mr Prouſt has diſcovered this ore in Spain. Its colour is greeniſh white. Its texture granular. Inſoluble in water and nitric acid. When melted on charcoal, the arſenical acid eſcapes with efferveſcence *.

* Ann. de Chim. i. 195.

229 Sulphat of iron.

SPECIES 3. Sulphat of iron.

For a deſcription of this ſalt, ſee CHEMISTRY, n° 631. in this *Suppl.*

ORDER VII. TIN ORES (H).

TIN is employed to cover plates of iron and copper, and to ſilver the backs of looking glaſſes: It enters into the compoſition of pewter; and forms a very important article in dyeing.

230 Mines.

Tin ores are by no means ſo common as the ores of the metals which we have already deſcribed. They are found only in the *primitive mountains* (I). Hence Werner ſuppoſes them to be the moſt ancient of all metallic ores. They occur moſt frequently in granite, ſometimes in porphyry, but never in limeſtone.

Almoſt

(G) *Kirw.* II. 190.—*Bergman*, II. 184.—*Bayen. Jour. de Phyſ.* VII. 213.— *Razowmowſki, Mem. Lauſanne*, 1783, p. 149.

(H) *Geoffroy, Mem. Par.* 1738, p. 103. —*Morveau, Ann. de Chim.* XXIV. 127.

(I) Geologiſts have divided mountains into three claſſes; *primitive, ſecondary*, and *tertiary*. The *primitive* occupy the centre of all extenſive chains; they are the higheſt, the moſt rugged, and exhibit the moſt pointed tops. They are conſidered as the moſt ancient mountains of the globe.

The *ſecondary* mountains occupy the outſide of extenſive ranges. They are uſually compoſed of ſtrata, more or leſs inclined, and commonly reſt againſt the ſides of the primitive mountains.—The *tertiary* mountains are much ſmaller than the others, and are often ſolitary. We uſe the terms *primitive, ſecondary*, &c. merely as proper

Tin Ores.

Almoft the only tin mines known to Europeans are thofe of Cornwal, Devonfhire, Saxony, Bohemia, Silefia, Hungary, Gallicia; thofe of the ifland of Banca and the peninfula of Malacca in India; and thofe of Chili and Mexico and America.

231 G. I. Sulphurets. Sulphuret of tin and copper

GENUS I. SULPHURETS OF TIN.

SPECIES 1. Sulphuret of tin and copper *.

Tin pyrites.

Hitherto this ore has only been found in Cornwal. There is a vein of it in that county, in the parifh of St Agnes, nine feet wide, and twenty yards beneath the furface †.

Its colour is yellowifh grey, paffing into the fteel grey. Not unlike grey copper ore. Luftre metallic. Hardnefs 5 to 6. Very brittle. Sp. gr. 4.35 ‡. Before the blow-pipe it melts eafily, with a fulphureous fmell, into a black bead, and depofits a bluifh oxide on the charcoal.

The compofition of this ore, as Klaproth informs us, was firft difcovered by Mr Rafpe. According to Klaproth's analyfis, it is compofed of

34	tin,
36	copper,
25	fulphur,
3	iron,
2	earth.
100 §	

* Kirw. ii. 200.

† Klaproth's Cornwal, p. 21.

‡ Klaproth.

§ Id. 58.

232 G. II. Oxides. Brown oxide of tin

GENUS II. OXIDES OF TIN.

SPECIES 1. Brown oxide of tin *.

Tinftone—Woodtin.

This ore, which may be confidered as almoft the only ore of tin, occurs in maffes, in rounded pieces, and cryftallized. Thefe cryftals are very irregular. Hauy fuppofes, that their primitive form is a cube †; but Romé de Lifle, with more probability, makes it an octohedron ‡; and in this opinion Mr Day agrees with him ||. The octohedron is compofed of two four-fided pyramids, applied bafe to bafe. The fides of the pyramids are ifofceles triangles, the angle at the vertex of which is 70°, and each of the other angles 55°. The fides of the two pyramids are inclined to each other at an angle of 90° §. The primitive form, however, never occurs, but cryftals of tinftone are fometimes found, in which the two pyramids are feparated by a prifm. For a complete defcription of the varieties of the cryftals of tinftone, we refer the reader to *Romé de Lifle* and *Mr Day* *.

* Kirw. ii. 197.

† Jour. de Min. No xxxii. 576.

‡ Cryftallog. iii. 413.

|| Philof. Mag. iv. 152.

§ Romé de Lifle, ibid.

Metalic Ores.

Its colour is commonly brown. Streak grey. Hardnefs 9 to 10. Sp. gr. 6.9 to 7.0. Brittle.

Variety 1. Common tinftone.

Colour dark brown; fometimes yellowifh grey, and fometimes nearly white. Streak light grey. Somewhat tranfparent when cryftallized. Hardnefs 10. Sp gr. 6.9 to 6.97. Before the blow-pipe it decrepitates, and on charcoal is partly reduced. Tinges borax white.

According to Klaproth, it is compofed of

77.50	tin,
21.50	oxygen,
.25	iron,
.75	filica.
100.00 †	

* Philof. Mag. ibid.

† Beiträge, ii. 256.

Variety 2. Woodtin.

This variety has hitherto been found only in Cornwal. It occurs always in fragments, which are generally rounded. Colour brown; fometimes inclining to yellow. Streak yellowifh grey. Opaque. Texture fibrous. Hardnefs 9. Sp. gr. 7.0. Before the blow-pipe becomes brownifh red; decrepitates when red hot, but is not reduced.

Klaproth obtained from it .63 of tin; and, in all probability, it is an oxide of tin nearly pure.

ORDER VIII. ORES OF LEAD.

The ufeful purpofes to which lead in its metallic ftate is applied, are too well known to require defcription. Its oxides are employed in painting, in dyeing, and fometimes alfo in medicine.

Ores of lead occur in great abundance in almoft every part of the world. They are generally in veins; fometimes in filiceous rocks, fometimes in calcareous rocks.

GENUS I. SULPHURETS OF LEAD. 233 G. I. Sulphurets. Galena, or pure fulphuret of lead.

SPECIES 1. Galena, or pure fulphuret of lead ‡.

This ore, which is very common, is found both in maffes and cryftallized. The primitive form of its cryftals is a cube. The moft common varieties are the cube, fometimes with its angles wanting, and the octohedron, compofed of two four-fided pyramids applied bafe to bafe: The fummits of thefe pyramids are fometimes cuneiform, and fometimes their folid angles are wanting ||.

Its colour is commonly bluifh grey, like lead. Streak bluifh grey and metallic. Luftre metallic. Sometimes ftains

‡ Kirw. ii. 216.

|| Romé de Lifle, iii. 364.

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proper names, without affirming or denying the truth or falfehood of the theory on which thefe names are founded. That the reader may have a more accurate idea of the compofition of thefe different claffes of mountains, we have fubjoined a lift of the fubftances which, according to Werner, enter into the compofition of each.

I. PRIMARY MOUNTAINS.

1. Granite,	4. Argillaceous fhiftus,	7. Shiftofe porphyry,	10. Serpentine,
2. Gneifs,	5. Syenite,	8. Quartz,	11. Topaz rock.
3. Micaceous fhiftus,	6. Porphyry,	9. Primitive limeftone,	

II. SECONDARY MOUNTAINS.

1. Argillaceous fhiftus,	3. Secondary limeftone,	5. Grunftein,
2. Rubble ftone,	4. Shiftofe hornblende,	6. Amygdaloid.

III. TERTIARY MOUNTAINS.

1. Trap,	4. Sandftone,	7. Chalk,	10. Ferruginous clay,
2. Argillaceous fhiftus,	5. Breccia,	8. Sulphat of lime,	11. Potters earth.
3. Stratified limeftone,	6. Coal,	9. Rock falt,	

Ores of Lead. ſtains the fingers. Texture foliated. Fragments cubical. Hardneſs 5 to 7; ſometimes even 9. Brittle. Sp. gr. 6.884 to 7.786 §. Effervefces with nitric and muriatic acids. Before the blow-pipe decrepitates, and melts with a ſulphureous ſmell; part ſinks into the charcoal.

§ Watſon.

It is compoſed of from .45 to .83 lead, and from .086 to .16 of ſulphur. It generally contains ſome ſilver, and ſometimes alſo antimony and zinc.

Variety 1. Common galena.

This variety correſponds nearly with the above deſcription. Sp. gr. 7.051 to 7.786. Sometimes ſtains the fingers.

Compact galena.

Found only in amorphous maſſes. Texture compact, inclining to foliated. Hardneſs 6 to 8. Sp. gr. 6.886 to 7.444. Luſtre common. Streak lead grey, brighter and metallic. Often feels greaſy, and ſtains the fingers.

234 Sulphuret of lead, with ſilver and antimony.

SPECIES 2. Sulphuret of lead, with ſilver and antimony*.

Plumbiferous antimoniated ſilver ore.

Found in amorphous maſſes. Colour grey. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.2 to 8.

* Kirw. ii. 119.

Variety 1. Light grey ſilver ore.

Colour light bluiſh grey. Streak light bluiſh grey, and brighter. Luſtre metallic. Texture compact. Before the blow-pipe partly evaporates, and leaves a ſilver bead on the charcoal, ſurrounded by yellow duſt.

According to Klaproth, it contains

48.06	lead,
20.40	ſilver,
7.88	antimony,
12.35	ſulphur,
2.25	iron,
7.00	alumina,
.25	ſilica.
98.09 †	

† Beitrāge, i. 172.

Variety 2. Dark grey ſilver ore.

Colour iron grey, verging on black. Powder black, and ſtains the fingers. Luſtre 0, Texture earthy.

According to Klaproth, it contains

41.00	lead,
21.50	antimony,
29.25	ſilver,
22.00	ſulphur,
1.75	iron,
1.00	alumina,
.75	ſilica.
97.25 ‡	

‡ Ibid. 175.

235 Blue lead ore.

SPECIES 3. Blue lead ore *.

This ore, which is found in Siberia, Germany, and Hungary, and is very rare, occurs ſometimes in maſſes, and ſometimes cryſtallized in ſix-ſided priſms.

* Kirw. ii. 220.

Colour between indigo blue and lead grey; ſometimes inclining to black. Internal luſtre metallic. Streak brighter. Texture compact. Hardneſs 6. Sp. gr. 5.461 †. Before the blow-pipe melts with a low blue flame and a ſulphureous ſmell, and is eaſily reduced.

† Gellert.

236 Black lead ore.

SPECIES 4. Black lead ore ‡.

This ore, which is found in Germany and Brittanny,

‡ Kirw. 221.

and which is ſuppoſed to be common galena decayed, is ſometimes in ſtalactites of various forms, and ſometimes cryſtallized in ſix-ſided priſms, which are generally truncated and confuſed. Metallic Ores.

Colour black, often with ſome ſtreaks of red. Streak light bluiſh grey. Internal luſtre metallic. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.744 ‖ to 5.77*. Before the blow-pipe decrepitates, melts eaſily, and is reduced.

‖ Briſſon. * Gellert.

According to the experiments of Laumont, this ore is a ſulphuret of lead (or rather ſulphuret of oxide of lead), mixed with ſome phoſphat of lead.

237 Sulphuret of lead, biſmuth, and ſilver.

SPECIES 5. Sulphuret of lead, biſmuth, and ſilver.

This ore, which occurs in the valley of Schapbach in Saxony, was firſt taken notice of by Selb, and afterwards deſcribed by Weidenmann and Emerling.

Its colour is light bluiſh grey. Its luſtre metallic Its fracture uneven. Hardneſs 5. Melts eaſily before the blow-pipe, emitting ſome ſmoke, and leaves a ſilver bead.

A ſpecimen, analyſed by Mr Klaproth, contained

33.0	lead,
27.0	biſmuth,
15.0	ſilver,
16.3	ſulphur,
4.3	iron,
0.9	copper.
96.5 †	

† Beitrāge, ii. 297.

238 G. II. Oxides. Lead ochre.

Genus II. Oxides of Lead.

SPECIES 1. Lead ochre ‡.

This ore, which is a mixture of the oxide of lead with various earths, is found maſſive, and various degrees of hardneſs.

‡ Kirw. ii. 205.

Its colour is either yellow, grey, or red. Luſtre 0. Tranſparency 0 to 1. Hardneſs 6 to 8; ſometimes in powder. Sp. gr. from 4.165 to 5.545 §. Texture compact. Effervefces with nitric and muriatic acids. Eaſily reduced by the blow-pipe, leaving a black ſlag, unleſs the lead be mixed with too great a proportion of earth.

§ Kirwan.

239 G. III. Salts. Carbonat of lead.

Genus III. Salts of Lead.

SPECIES 1. Carbonat of lead ‡.

White lead ſpar.

This ore of lead, which is very common, is ſometimes in maſſes, and ſometimes cryſtallized. But the cryſtallization is in general ſo confuſed, that the primitive form of the cryſtals has not yet been aſcertained (K).

‡ Kirw. ii. 203.

Its colour is white. External luſtre, waxy or ſilky, from 3 to 1; internal 1 to 2. Generally ſomewhat tranſparent. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.349 ‖ to 6.92 §. Effervefces with nitric and muriatic acids when they are heated. Soluble in fat oils. Blackened by ſulphuret of ammonia*. Decrepitates when heated. Before the blow-pipe, in a ſilver ſpoon, it becomes red by the yellow cone of the flame, while the blue cone renders it yellow †. On charcoal it is immediately reduced.

‖ Kirwan. § Gellert. * Pelletier, Ann. de Chim. ix. 56. † Ribbentropp, Ann. de Chim. xxv. 189.

It contains from .60 to .85 of lead, and from .18 to .24 of carbonic acid. It is generally contaminated with carbonat of lime and oxide of iron.

(K) See *Hauy*, *Jour. de Min.* N° XXXI. 502. and *Romé de Liſle*, III. 380.

Ores of Lead.

SPECIES 2. Phofphat of lead *.

240 Phofphat of lead. * Kirw. ii. 207.

This ore, which is found in Siberia, Scotland, England, Germany, Carinthia, Brittany, &c. is fometimes amorphous, and fometimes cryftallized. The primitive form of its cryftals, according to Romé de Lifle, is a dodecahedron, confifting of a fix-fided rectangular prifm, terminated by fix-fided pyramids, the fides of which are ifofceles triangles (L). Sometimes the pyramids are truncated, and even altogether wanting. The cryftals of this ore are often acicular.

Its colour is commonly green; fometimes yellowifh or brownifh, or greyifh white. Streak commonly greenifh white. Powder yellowifh. External luftre, waxy, 2 to 3. Somewhat tranfparent, except when its colour is greyifh white. Hardnefs 5 to 6. Brittle. Sp. gr. from 5.86* to 6.27†. Infoluble in water and fulphuric acid, and nearly infoluble in nitric acid; foluble in hot muriatic acid, with a flight effervefcence ‡. Before the blow-pipe it eafily melts on charcoal, and cryftallizes on cooling: with foda the lead is in fome meafure reduced.

* Briffon. † Klaproth. ‡ Fourcroy, Ann. de Chim. ii. 207.

The compofition of this ore was firft difcovered by Gahn.

According to Fourcroy's analyfis, a fpecimen from Erlenbach in Alface confifts of

96	phofphat of lead,
2	phofphat of iron,
2	water.
100	

Or it contains

79	oxide of lead,
1	oxide of iron,
18	phofphoric acid,
2	water.
100 ¶	

¶ Ibid.

SPECIES 3. Arfeniat of lead §.

241 Arfeniat of lead. § Kirw. ii. 209.

This ore, which has hitherto been found only in Andalufia in Spain, and always in quartz or feldfpar, is in fmall maffes. Colour meadow green, often paffing into wax yellow. Luftre waxy, 2. Tranfparency 2. Before the blow-pipe it melts, and retains its colour, and does not cryftallize on cooling. When heated to whitenefs, the arfenic acid efcapes, and the lead is reduced*.

* Prouft, Jour. de Phyf. xxx. 394.

SPECIES 4. Phofphat and arfeniat of lead.

Aefenio phofphat of lead †.

242 Phofphat and arfeniat of lead. † Kirw. ii. 210.

This ore, which has been found in Auvergne in France, is either in maffes, or cryftallized in fmall fix-fided prifms, with curvilineal faces.

Colour yellowifh green, or fhews alternate layers of pale and light green. Powder yellowifh. The cryftals are fomewhat tranfparent; but when maffive, this ore is opaque. Hardnefs 5 to 7. Brittle. Sp. gr. 6.8465 ‡. Soluble in hot muriatic acid, but not in nitric. When heated it decrepitates. Before the blow-pipe melts eafily, effervefces, emits a white fmoke, with an arfenical fmell. Some particles of lead are reduced, a brown fluid remains, which cryftallizes on cooling like phofphat of lead.

‡ Briffon.

Metallic Ores.

According to Fourcroy, from whom the whole of this defcription has been taken, it is compofed of

65	arfeniat of lead,
27	phofphat of lead,
5	phofphat of iron,
3	water.
100*	

* Ann. de Chim. ii. 23.

SPECIES 5. Molybdat of lead (M).

243 Molybdat of lead.

This ore, which is found in Carinthia and at Leadhills in Scotland, was firft mentioned in 1781 by Mr Jacquin (N). It occurs either in maffes, or cryftallized in cubic, or rhomboidal, or octohedral plates.

Its colour is yellow. Streak white. Luftre waxy. Generally fomewhat tranfparent. Texture foliated. Fracture conchoidal. Hardnefs 5 to 6. Sp. gr. 5.486†; when purified from its gangue by nitric acid, 5.706‡. Soluble in fixed alkalies and in nitric acid. Communicates a blue colour to hot fulphuric acid. Soluble in muriatic acid, and decompofed by it. Before the blowpipe decrepitates, melts into a yellowifh grey mafs, and globules of lead are reduced ‖.

† Macquart. ‡ Hatchett. ‖ Macquart.

Klaproth firft proved that this ore was molybdat of lead.

A very pure fpecimen, analyfed by him, contained

64.42	oxide of lead,
34.25	molybdic acid,
98.67 ¶	

¶ Beiträge, ii. 275.

According to the analyfis of Mr Hatchett, it is compofed of

58.40	oxide of lead,
38.00	molybdic acid,
2.10	oxide of iron,
.28	filica.
98.78*	

* Phil. Tranf. lxxxvi. 323.

Macquart found a fpecimen to contain

58.74	lead,
4.76	oxygen,
28.00	molybdic acid,
4.50	carbonat of lime,
4.00	filica.
100.00†	

Its gangue is carbonat of lime.

† Jour. de Min. N° xvii. 32.

SPECIES 6. Sulphat of lead *.

244 Sulphat of lead.

This ore, which is found in Anglefey and in Andalufia, is generally cryftallized. The cryftals are regular octahedrons †, and very minute.

Colour white. Luftre 4. Tranfparency 4. Before the blow-pipe it is immediately reduced.

The compofition of this ore was firft afcertained by Dr Withering.

* Kirw. Min. ii. 211. † Hauy, Jour. de Min. N° xxxi. 508.

Order IX. ORES OF ZINC.

Hitherto zinc has not been applied to a great variety of ufes. It enters into the compofition of brafs; it is ufed in medicine; and Morveau has fhewn that its oxide

(L) *Cryftal.* III. 391. See alfo *Hauy's* remarks on the fame fubject in the *Jour. de Min.* N° XXXI. 506.
(M) *Kirw.* II. 212.—*Klaproth, Ann. de Chim.* VIII. 103.—*Hatchett, Phil. Tranf.* 1796, p. 285.
(N) In his *Mifcellanea Auftriaca*, Vol. II. p. 139.

Ores of Zinc.

oxide might be employed with advantage as a white paint.

Ores of zinc are very abundant; they generally accompany lead ores, particularly galena. Calamine, or oxide of zinc, has never been discovered in the primitive mountains.

245 G I. Sulphurets. Common sulphuret of zinc.

GENUS I. SULPHURETS OF ZINC.

SPECIES I. Common sulphuret of zinc *.

Blende.

This ore very commonly accompanies sulphuret of lead. It occurs both in amorphous masses and crystallized. The primitive form of its crystals is a rhomboidal dodecahedron, consisting of a six-sided prism, terminated by three-sided pyramids. All the faces of the crystals are equal rhombs. This dodecahedron may be mechanically divided into four equal rhomboidal parallelopipeds, and each of these into six tetrahedrons, whose faces are equal isosceles triangles. The figure of its integrant particles is the tetrahedron, similar to these †.

The principal varieties of its crystals are the tetrahedron; the octohedron; the octohedron with its edges wanting ‡; a 24-sided crystal, 12 of whose faces are trapezoids, and 12 elongated triangles §; and, lastly, a 28-sided figure, which is the last variety, augmented by four equilateral triangles ‖.

Colour yellow, brown, or black. Streak reddish, brownish, or grey. Lustre commonly metallic. Generally somewhat transparent. Texture foliated. Hardness 6 to 8. Sp. gr. 3.93 * to 4.1665 †. Before the blow-pipe decrepitates, and gives out white flowers of zinc, but does not melt. Borax does not affect it. When breathed upon, loses its lustre, and recovers it very slowly ‡.

Variety 1. Yellow blende.

Colour commonly sulphur yellow, often passing into olive green or brownish red. Powder pale yellow. Streak yellowish or reddish grey, not metallic. Lustre metallic. Transparency 2 to 4. Often phosphoresces when scraped or rubbed §.

According to Bergman, it is composed of

64	zinc,
20	sulphur,
5	iron,
4	fluor acid,
1	silica,
6	water.
100 ‖	

Variety 2. Brown blende.

Colour different shades of brown. Surface often tarnished. Powder brownish grey. Streak reddish or yellowish grey, not metallic. Lustre commonly metallic. Transparency 0 to 2.

A specimen of this variety, analysed by Bergman, contained

44	zinc,
17	sulphur,
24	silica,
5	iron,
5	alumina,
5	water.
100 ¶	

Variety 3. Black blende.

Colour black, or brownish black; surface often tarnished blue; tips of the crystals often blood red. Powder brownish black. Streak reddish, brownish, or grey. Lustre common or metallic. Transparency 0 to 1; the red parts 2. Hardness 8.

A specimen of this variety, analysed by Bergman, contained

52	zinc,
26	sulphur,
4	copper,
8	iron,
6	silica,
4	water.
100 *	

* Kirw. ii. 238.—Berg. ii. 329.
† Hauy, Jour. de Min. No xxxiii. 669.
‡ Fig. 40.
§ Fig. 41.
‖ See Hauy, ibid. and Romé de Lisle, iii. 65.
* Gillert.
† Brisson.
‡ Hauy, Jour. de Min. ibid.
§ Bergman, ii. 345.
‖ Ibid. 347.
¶ Ibid. 333.
* Bergman, ii. 335.

Metallic Ores.

246 G. II. Oxides. White oxide of zinc.

GENUS II. OXIDES OF ZINC.

SPECIES I. White oxide of zinc †.

Calamine.

This ore is either found loose, or in masses, or crystallized. The primitive form of its crystals appears, from the mechanical division of one of them by Mr Hauy, to be an octohedron composed of two four-sided pyramids, whose sides are equilateral triangles ‡. But the crystals are minute, and their figure not very distinct. They are either four or six-sided tables with bevelled edges, six-sided prisms, or three-sided pyramids.

Colour commonly white, grey, or yellow. Lustre often 0, sometimes 2 or 1. Opaque. The crystals are somewhat transparent. Hardness from 4 to 9, sometimes in powder. Sp. gr. from 2.585 to 3.674 §. When heated, becomes electric, without friction, like the tourmaline ‖. Not blackened by sulphuret of ammonia. Soluble in sulphuric acid. Before the blow-pipe decrepitates, and does not melt.

This ore consists of oxide of zinc more or less contaminated with iron, silica, lime, and other foreign ingredients. In one specimen Bergman found the following ingredients:

84	oxide of zinc,
3	oxide of iron,
12	silica,
1	alumina.
100 ¶	

In another specimen, which gelatinized with acids like zeolite, Klaproth found

66	oxide of zinc,
33	silica,
99	

In another specimen, analyzed by Pelletier, the contents were

52	silica,
36	oxide of zinc,
12	water.
100 *	

Mr Kirwan has divided this species into three varieties.

Variety 1. Friable calamine.

In masses which easily crumble between the fingers. Lustre 0. Opaque. Texture earthy. When its colour is white, it is pure oxide of zinc; when yellow, it is mixed with oxide of iron. The white often becomes yellow when placed in a red heat, but resumes its colour on cooling. Common in China, where it is called *wohan* or *ore of Tutenago*.

† Kirw. ii. 233.—Berg. ii. 321.
‡ Jour. de Min. No xxxii. 596.
§ Kirwan.
‖ Hauy, Jour. de Min. ibid.
¶ Bergman, ii. 323.
* Jour. de Phys. xx. 428.

Ores of Antimony.

Variety 2. Compact calamine.

Colour different fhades of grey; fometimes yellow or brownifh red. Luftre 0. Opaque. Texture compact.

Variety 3. Striated calamine.

This variety alone is found cryftallized; but, like the others, it is alfo often amorphous. Colour white, and alfo various fhades of grey, yellow, and red. Somewhat tranfparent. Texture ftriated. Luftre 2 to 1.

247 G. III. Salts. Sulphat of zinc.

GENUS III. SALTS OF ZINC.

SPECIES 1. Sulphat of zinc.

For a defcription of this falt, we refer to CHEMISTRY, n° 643. *Suppl.*

ORDER X. ORES OF ANTIMONY.

Antimony is much ufed to give hardnefs to thofe metals which otherwife would be too foft for certain purpofes: printers types, for inftance, are compofed of lead and antimony. It is ufed alfo in medicine.

Ores of antimony are found abundantly in Germany, Hungary, France, Spain, Britain, Sweden, Norway, &c. They often accompany galena and hæmatites. They are found both in the fecondary and primitive ftratified mountains. Their gangue (o) is often quartz and fulphat of barytes.

248 G. I. Alloys Native antimony.

GENUS I. ALLOYS OF ANTIMONY.

SPECIES 1. Native antimony *.

This mineral, which was firft difcovered by Dr Swab, has been found in Sweden and in France, both in maffes and kidney fhaped lumps. Colour white, between that of tin and filver. Luftre metallic. Texture foliated. Hardnefs 6. Sp. gr. above 6. Deflagrates with nitre. Before the blow-pipe melts and evaporates, depofiting a white oxide of antimony.

It confifts of antimony, alloyed with 3 or 4 *per cent.* of arfenic.

* *Kirw.* ii. 245.

249 G. II. Sulphurets. Grey ore of antimony.

GENUS II. SULPHURETS OF ANTIMONY.

SPECIES 1. Grey ore of antimony *.

This ore, which is the moft common, and indeed almoft the only ore of antimony, occurs both maffive, diffeminated, and cryftallized. Its cryftals are four-fided prifms, fomewhat flattened, whofe fides are nearly rectangles, terminated by fhort four-fided pyramids, whofe fides are trapeziums †. Sometimes two of the edges are wanting, which renders the prifm fix-fided ‡.

Colour grey. Luftre metallic. Streak grey, metallic, and brighter. Powder black or greyifh black. Hardnefs 6 to 7. Sp. gr. from 4.1327 to 4.516 §. Often ftains the fingers. Before the blow-pipe melts eafily, burns with a blue flame, and depofits a white oxide on the charcoal. When placed in an open veffel, over a flow fire, the fulphur evaporates, and leaves a grey oxide of antimony. This oxide, if fufed with tartar, is reduced.

This ore, when taken out of the mine, almoft always contains a large proportion of quartz or other ftony matter. When pure, it is compofed of about

74	antimony,
26	fulphur.
100	

* *Kirw.* ii. 247.
† *Romé de Lifle*, iii. 49.
‡ *Ibid.*—See alfo *Hauy*, *Jour. de Min.* N° xxxii. 606.
§ *Briffon.*

Metallic Ores.

Werner has divided this fpecies into three varieties.

Variety 1. Compact fulphuret.

Colour bluifh grey, furface often tarnifhed, and then it is blue or purplifh. Luftre 1 to 2. Texture compact. Fracture fine grained, uneven. Powder black, dull, and earthy. Slightly ftains the fingers.

Variety 2. Foliated fulphuret.

Colour light fteel grey. Luftre 3 to 4. Texture foliated. Powder as that of the laft variety.

Variety 3. Striated fulphuret.

Colour dark fteel grey, and light bluifh grey, furface often tarnifhed, and then it is dark blue or purplifh. Luftre 3 to 2. Texture ftriated. Powder greyifh black. This variety alone has been hitherto found cryftallized.

250 Plumofe antimonial ore.

SPECIES 2. Plumofe antimonial ore †.

Sulphurets of antimony and arfenic.

This fpecies, which is fometimes found mixed with the cryftals of fulphurated antimony, is in the form of brittle, capillary, or lanuginous cryftals, often fo fmall that they cannot be diftinctly feen without a microfcope.

Colour fteel or bluifh grey, often tarnifhed, and then brown or greyifh black. Luftre 1, femimetallic. Before the blow-pipe emits a fmoke, which depofits a whitifh and yellowifh powder on the charcoal: it then melts into a black flag.

It is fuppofed to confift of fulphur, antimony, arfenic, and fome filver.

† *Kirw.* ii. 250.

251 Red antimonial ore.

SPECIES 3. Red antimonial ore †.

Hydrofulphuret of antimony.

This fpecies is generally found in cavities of fulphurated antimonial ore. It is cryftallized in delicate needles, often diverging from a common centre.

Colour red. Luftre 2, filky. Sp. gr. 4.7. Before the blow-pipe melts eafily, and evaporates with a fulphureous fmell.

This ore has not been analyfed. Mineralogifts have fuppofed it to be a natural kermes. If fo, we may conclude, from the experiments of Berthollet *, that it is a hydrofulphuret of antimony, and confequently compofed of oxide of antimony, fulphur, and fulphurated hydrogen gas.

† *Kirw.* ii. 250.
* *Ann. de Chim.* xxv. 259.

252 G. III. Oxides of antimony.

GENUS III. OXIDES OF ANTIMONY.

There is a fubftance found incumbent on fulphuret of antimony, of a yellow colour, and an earthy appearance, which has been fuppofed an oxide of antimony, and denominated antimonial ochre. But hitherto it has not been analyfed.

GENUS

(o) The word *gang* is ufed by German mineralogifts to denote a metallic vein. Now, it is not often that thefe veins confift entirely of *ore*; in general, they contain ftony matter befides. For inftance, in the copper mine at Airthry, near Stirling, the copper ore is merely a narrow ftripe in the middle of the vein, and the reft of it is filled up with fulphat of barytes. We ufe the word *gangue* (as the French do), to denote, not the *metallic* vein, but the *ftony* matter which accompanies the ore in the vein. The gangue of the copper ore at Airthry is fulphat of barytes.

Ores of Biſmuth. Metallic Ores.

253 G. IV. Salts. Muriat of antimony. * Kirw. ii. 251.

GENUS IV. SALTS OF ANTIMONY.

SPECIES 1. Muriat of antimony *.

This ore, which has been found in Bohemia, is ſometimes in quadrangular tables; ſometimes in acicular cryſtals grouped like zeolites; and ſometimes in priſms.

Colour pale yellowiſh or greyiſh white. Luſtre 3 to 1, nearly metallic. Tranſparency 2. Texture foliated. Melts eaſily by the flame of a candle, and emits a white vapour †. Before the blow-pipe decrepitates; when powdered, and juſt ready to melt, it evaporates, and leaves a white powder around. Between two pieces of coal it is reducible to a metallic ſtate.

† Hauy, Jour. de Min. N° xxxii. 609.

ORDER XI. ORES OF BISMUTH *.

* Pott, Obſerv. Chym. 134—Geoffroy, Mem. Par. 1753, p. 296.

BISMUTH is employed in the manufacture of pewter, of printers types, in ſoldering; and perhaps alſo its property of rendering other metals more fuſible, might make it uſeful in anatomical injections. The quantity conſumed in commerce is not great.

It has been found only in the primitive mountains, and is by no means common. When unaccompanied by any other metal, it does not form veins, but kidney-form maſſes. It often accompanies cobalt. Its gangue is commonly quartz. Its ores are not very abundant. They have been found chiefly in Sweden, Norway, Tranſylvania, Germany, France, and England.

254 G. I. Alloys. Native biſmuth. * Kirw. ii. 264.

GENUS I. ALLOYS OF BISMUTH.

SPECIES 1. Native biſmuth *.

This mineral, which is found at Schneeberg, Johangeorgenſtadt, &c. in Germany, has commonly the form of ſmall plates lying above one another. Sometimes it is cryſtallized in four-ſided tables, or indiſtinct cubes.

Colour white with a ſhade of red; ſurface often tarniſhed red, yellow, or purple. Luſtre metallic, 3 to 2. Opaque. Texture foliated or ſtriated. Hardneſs 6. Sp. gr. 9.022 † to 9.57 ‡. Exceedingly fuſible. Before the blow-pipe gives a ſilvery white bead, and at laſt evaporates in a yellowiſh white ſmoke, which is depoſited on the charcoal.

† Briſſon. ‡ Kirwan.

It is generally accompanied by cobalt, and ſometimes contains arſenic.

255 G. II. Sulphurets. Common ſulphuret of biſmuth. * Kirw. ii. 266.—Sage, Mem. Par. 1782, 307.

GENUS II. SULPHURETS OF BISMUTH.

SPECIES 1. Common ſulphuret of biſmuth *.

This ore, which is found in Sweden, Saxony, and Bohemia, occurs ſometimes in amorphous maſſes, and ſometimes in needleform cryſtals.

Colour commonly bluiſh grey, ſometimes white; ſurface often tarniſhed yellow, red, and purple. Powder black and ſhining. Luſtre metallic, 2 to 3. Streak obſcurely metallic. Texture foliated. Hardneſs 5. Brittle. Sp. gr. 6.131 † to 6.4672 ‡. When held to the flame of a candle, it melts with a blue flame and ſulphureous ſmell. Before the blow-pipe emits a reddiſh yellow ſmoke, which adheres to the charcoal. This powder becomes white when it cools, and reſumes its former colour when the flame is directed upon it *.

† Kirwan. ‡ Briſſon.

* Gillot, Jour. de Min. N° xxxii. 585.

This ore, according to Sage, contains 60 biſmuth. And, according to La Perouſe, it holds 36 ſulphur.

99

A ſpecimen, analyſed by Klaproth, contained

95 biſmuth,
5 ſulphur.

100 †

It is commonly accompanied by quartz, aſbeſtos, or ſparry iron ore.

† Beitrâge, i. 256.

256 G. III. Oxides. Yellow oxide of biſmuth. ‡ Kirw. ii. 263.

GENUS III. OXIDES OF BISMUTH.

SPECIES 1. Yellow oxide of biſmuth ‡.

Biſmuth ochre.

This ore generally accompanies the two ſpecies already deſcribed. It is found in two ſtates; either of an earthy conſiſtence, or cryſtallized in cubes or quadrangular plates.

Colour uſually greeniſh yellow, ſometimes grey. Soluble in nitrous acid without effervefcence, and may in a great meaſure be precipitated by the effuſion of water.

ORDER XII. ORES OF ARSENIC.

ARSENIC is uſed as an alloy for ſeveral other metals, eſpecially copper. It is ſometimes employed to facilitate the fuſion of glaſs, or to render it opaque, in order to form an enamel. Preparations of arſenic are employed as paints; and, like moſt other violent poiſons, it has been introduced into medicine.

This metal is ſcattered in great abundance over the mineral kingdom, accompanying almoſt every other metal, and forming alſo ſometimes peculiar veins of its own. Of courſe it occurs in almoſt every ſpecies of mountain, and is accompanied by a variety of gangues.

257 G. I. Alloys. Native arſenic. † Kirw. ii. 255.

GENUS I. ALLOYS OF ARSENIC.

SPECIES 1. Native arſenic †.

This mineral is found in different parts of Germany. It occurs generally in maſſes of various ſhapes, kidney-form, botryoidal, &c.

Colour that of ſteel. Its ſurface quickly becomes tarniſhed by expoſure to the air. Luſtre metallic (when freſh), 2 to 3. Streak bluiſh grey, metallic, and bright. Powder dull and black. Texture compact. Hardneſs 7 to 8. Brittle. Sp. gr. 5.67 † to 5.7249 ‡. Gives an arſenical ſmell when ſtruck. Before the blow-pipe emits a white ſmoke, diffuſes a garlic ſmell, burns with a blue flame, gradually evaporates, depoſiting a white powder.

† Kirwan. ‡ Briſſon.

It is always alloyed with ſome iron §, and often contains ſilver, and ſometimes gold.

§ De Born. Catal. of M. Raab. ii. 194.

258 G. II. Sulphurets. Orpiment.

GENUS II. SULPHURETS OF ARSENIC.

SPECIES 1. Orpiment (P).

Auripigmentum.

This ore, which is found in Hungary, Wallachia, Georgia, and Turkey in Aſia, is either maſſive or cryſtallized. The cryſtals are confuſed, and their figure cannot be eaſily determined; ſome of them appear octohedrons, and others minute four-ſided priſms.

Its colour is yellow. Streak orange yellow. Luſtre waxy, 2 to 3. Tranſparency from 0 to 2. Texture foliated. Hardneſs 4 to 8 Sp. gr. from 3.048 * to 3.521 †. Effervefces with hot nitric acid. Burns with a

* Kirwan. † Gillert.

(P) *Kirw.* II. 260.—*Alberti de Auripigmento.*—*Scopoli in Anno 5to Hiſt. Naturali*, p. 59.—*Berg.* II. 297.

Ores of Arſeniac.

a bluiſh white flame. Before the blow-pipe melts, ſmokes, and evaporates, leaving only a little earth and ſome traces of iron.

Compoſed of 80 ſulphur,
20 arſenic.

100

259 Realgar.
* Kirw. ii. 261.—Berg. ii. 297.

SPECIES 2. Realgar *.

This mineral is found in Sicily, about Mount Veſuvius, in Hungary, Tranſylvania, and various parts of Germany. It is either maſſive or cryſtallized. The primitive form of the cryſtals is, according to Romé de Liſle, a four-ſided rhomboidal priſm, terminated by four-ſided pyramids, the ſides of which are rhombs †. It commonly appears in 4, 6, 8, 10, or 12 ſided priſms, terminated by four ſided ſummits ‡.

† Cryſtal. iii. 34.
‡ Ibid.

Colour red. Streak yellowiſh red. Powder ſcarlet. Luſtre 3 to 2. Tranſparency from 2 to 3; ſometimes 0. Hardneſs 5 to 6. Sp. gr. 3.3384 §. It is an electric *per ſe*, and becomes negatively electric by friction ‖. Nitric acid deprives it of its colour. Before the blow-pipe it melts eaſily, burns with a blue flame and garlic ſmell, and ſoon evaporates.

§ Briſſon.
‖ Hauy, Jour. de Min. N° xxxii. 612.

Compoſed of 20 ſulphur,
80 arſenic.

100

260 G. III. Oxides. White oxide of arſenic.
* Kirw. ii. 258—Berg. ii. 285.

GENUS III. OXIDES OF ARSENIC.

SPECIES 1. White oxide of arſenic *.

Native calx of arſenic.

This ore is found in various parts of Germany, Hungary, &c. either in powder, or maſſive, or cryſtallized in priſmatic needles.

Colour white or grey, often with a tint of red, yellow, green, or black. Luſtre common, 1 to 2. Tranſparency 1 to 0; when cryſtallized, 2. Texture earthy. Hardneſs 6. Brittle. Sp. gr. 3.7 †. Soluble in hot diluted nitric acid without effervefcence. Soluble at 60° Fahrenheit in 80 times its weight of water. Before the blow-pipe ſublimes, but does not inflame. Tinges borax yellow.

† Kirwan.

ORDER XIII. COBALT ORES.

COBALT is employed to tinge glaſs of a blue colour, and is uſeful in painting upon porcelain.

Cobalt ores are found almoſt excluſively in the ſtratified mountains, except one ſpecies, ſulphuret of cobalt, which affects the primitive mountains. They are not very abundant; and for that reaſon cobalt is more valuable than many of the other metals which have been already treated of. They are commonly accompanied by nickel, biſmuth, or iron. They are moſt abundant in Germany, Sweden, Norway, and Hungary; they have been found alſo in Britain and France, but not in any great quantity.

261 G. I. Alloys. Cobalt alloyed with arſenic.
† Kirw. ii. 270.

GENUS I. ALLOYS OF COBALT.

SPECIES 1. Cobalt alloyed with arſenic †.

Dull grey cobalt ore.

This ore, which occurs in different parts of Germany, is either amorphous or cryſtallized. The forms of its cryſtals are the cube; ſometimes the cube with its angles, or edges, or both wanting; and the octahedron ‡.

‡ Romé de Liſle, iii. 123.

Metallic Ores.

Its colour, when freſh broken, is whitiſh or bluiſh grey, ſometimes with a ſhade of red; when expoſed to the air it ſoon becomes tarniſhed. Streak bluiſh grey and metallic. Luſtre ſcarcely metallic, 0 to 1. Texture compact. Hardneſs 10. Difficultly frangible. Sp. gr. when amorphous, 5.309 to 5.571 §; when cryſtallized 7.7207 †. When ſtruck it gives out an arſenical ſmell. Before the blow-pipe it gives out an arſenical vapour, becomes magnetic, and melts eaſily, unleſs it contains a great quantity of iron. Tinges borax dark blue, and a ſmall metallic bead is obtained.

§ Kirw. ii. 270.
† Hauy, Jour. de Min. N° xxxii. 588.

A ſpecimen of this ore from Cornwall, examined by Mr Klaproth, contained 20 cobalt,
24 iron,
33 arſenic.

77

with ſome biſmuth and ſtony matter *.

* Klaproth's Cornwall, p. 61.

Another ſpecimen from Tunaberg, according to the analyſis of the ſame chemiſt, contained
55.5 arſenic,
44.0 cobalt,
.5 ſulphur.

100 †

† Beiträge, ii. 307.

262 G. II. Sulphurets. White cobalt ore.
‡ Kirw. ii. 273.—Sage, Jour. de Phy. xxxix. 53.

GENUS II. SULPHURETS OF COBALT.

SPECIES 1. White cobalt ore ‡.

Sulphuret of cobalt, arſenic, and iron.

The deſcriptions which different mineralogiſts have given of this ore are ſo various, that it is impoſſible not to ſuppoſe that diſtinct ſubſtances have been confounded together.

It occurs either in maſſes, or cryſtallized in cubes, dodecahedrons, octohedrons, and icoſahedrons.

Colour tin white, ſometimes tarniſhed reddiſh or yellowiſh. Powder ſteel grey. Luſtre partly metallic, and from 2 to 4; partly 0 or 1. Texture foliated. Hardneſs 8 to 9. Sp. gr. from 6.284 † to 6,4509 ‡. Before the blow-pipe generally gives out an arſenical vapour, and does not melt.

† Kirwan.
‡ Hauy.

The analyſes that have been given of this ore are very various. Sometimes it has been found to contain no arſenic nor iron, and ſometimes to contain both. A ſpecimen from Tunaberg in Sweden, which ought to belong to this ſpecies, was analyſed by Taſſaert, and found to conſiſt of 49 arſenic,
36.6 cobalt,
5.6 iron,
6.5 ſulphur.

97.7 †

† Ann. de Chim. xxviii. 100.

Klaproth found a ſpecimen of the ſame ore to contain 55.5 arſenic,
44.0 cobalt,
0.5 ſulphur.

100.0 ‡

‡ Beiträge, ii. 307.

263 G. III. Oxides. Black cobalt ore or ochre.
§ Kirw. ii. 275.

GENUS III. OXIDES OF COBALT.

SPECIES 1. Black cobalt ore or ochre §.

This ore, which occurs in different parts of Germany, is either in the form of powder, or indurated.

Colour black, often with a ſhade of blue, grey, brown, or green. Luſtre 0 to 1. Streak brighter. Hardneſs (of the indurated) from 4 to 8. Sp. gr. 3 to 4. Soluble in muriatic acid. Tinges borax blue.

SPECIES

Ores of Nickel.

294 own cobalt ore. Kirwan, 276.

SPECIES 2. Brown cobalt ore *.

Colour greyiſh or dark leather brown. Streak brighter, unctuous. Communicates a pale blue tinge in fuſion.

265 ellow cobalt ore. Ibid.

SPECIES 3. Yellow cobalt ore †.

Colour yellow. Dull and earthy. Hardneſs 4 to 5. Texture earthy. Streak brighter, unctuous. Gives a weak blue tinge.

266 G. IV. Salts. rſeniat of balt. Id. 278.

GENUS IV. SALTS OF COBALT.

SPECIES 1. Arſeniat of cobalt ‡.

Red cobalt ore.

This ſpecies, like moſt other ores of cobalt, has neither been accurately deſcribed nor analyſed.

It is found in maſſes of various ſhapes, and cryſtallized in quadrangular tables or acicular priſms.

Colour red. Luſtre from 2 to 3, ſometimes 0. Tranſparency 0 to 2. Hardneſs 5 to 7. Brittle. Before the blow-pipe becomes blackiſh grey. Diffuſes a weak arſenical ſmell. Tinges borax blue.

ORDER XIV. ORES OF NICKEL.

HITHERTO nickel has been found in too ſmall quantities to be applied to any uſe; of courſe there are, properly ſpeaking, no mines of nickel. It occurs only (as far as is yet known) in the ſecondary mountains, and it commonly accompanies cobalt. It has been found in different parts of Germany, in Sweden, Siberia, Spain, France, and Britain.

267 G. I. Sulphurets. Sulphuret of nickel with arſenic and iron. Ibid. 286.

GENUS I. SULPHURETS OF NICKEL.

SPECIES 1. Sulphuret of nickel with arſenic and iron.

*Kupfer nickel**.

This, which is the moſt common ore of nickel, occurs either maſſive or diſſeminated, but never cryſtallized.

Colour often that of copper, ſometimes yellowiſh white or grey. Recent fracture often ſilver white. Luſtre metallic, 2 to 3. Texture compact. Hardneſs 8. Sp. gr. 6.6086 to 6.6481 ‡. Soluble in nitric and nitro-muriatic acids. Solution green. Before the blowpipe exhales an arſenical ſmoke, and melts into a bead which darkens by expoſure to the air.

Briſſon.

It is compoſed of various proportions of nickel, arſenic, iron, cobalt, ſulphur; often contains biſmuth, and ſometimes ſilver and copper.

268 G. II. Oxides. Nickel ochre. Kirwan, 284.

GENUS II. OXIDES OF NICKEL.

SPECIES 1. Nickel ochre *.

This mineral occurs either in the form of a powder, or indurated, and then is either amorphous, or cryſtallized in acicular form cryſtals. The powder is generally found on the ſurface of other nickel ores.

Colour different ſhades of green. Luſtre 1 to 0. Texture earthy. Sp. gr. conſiderable. Slowly diſſolves in acids: ſolution green. Before the blow-pipe does not melt; but gives a yellowiſh or reddiſh brown tinge to borax.

This ore often contains ſulphat of nickel, which is ſoluble in water. The ſolution, when evaporated, gives oblong rhomboidal cryſtals, from which alkalies precipitate a greyiſh green oxide. This oxide is ſoluble by acids and by ammonia. The acid ſolution is green; the alkaline blue.

Metallic Ores

269 G. III. Salts. Arſeniat of nickel. † Kirwan, ii. 285.

GENUS III. SALTS OF NICKEL.

SPECIES 1. Arſeniat of nickel †.

This ore, which was lately diſcovered at Regendorff by Mr Gmelin, is found in ſhapeleſs maſſes, and is often mixed with plates of ſulphat of barytes.

Colour pale grey, here and there mixed with pale green. Streak white. Luſtre 0. Texture compact. Hardneſs 7. Difficultly frangible. Sp. gr. conſiderable. Adheres ſlightly to the tongue, and gives an earthy ſmell when breathed on. Soluble in hot nitric and muriatic acids: ſolution green.

Contains ſome cobalt and alumina.

ORDER XV. ORES OF MANGANESE (q).

HITHERTO mangaueſe, in its metallic ſtate, has ſcarcely been put to any uſe; but under the form of an oxide it has become of great importance. The oxide of manganeſe has the property of rendering colourleſs a variety of bodies which injure the tranſparency of glaſs; and it has been long uſed in glaſs manufactories for this purpoſe under the name of *glaſs ſoap*. By means of the ſame oxide, oxy-muriatic acid is prepared, which has rendered manganeſe of great importance in bleaching. Not to mention the utility of manganeſe to the chemiſt, the property which it has of facilitating the oxidation of other metals, and of rendering iron more fuſible—will probably make it, in no very remote period, of very conſiderable importance in numerous manufactories.

Ores of manganeſe occur often in ſtrata, both in the primitive and ſecondary mountains; ſcarcely ever, however, we believe, in thoſe mountains which are conſidered as the moſt ancient of all. They are very common, having been found abundantly in Germany, France, Spain, Britain, Sweden, Norway, Siberia, and other countries.

270 G. I. Oxides.

GENUS I. OXIDES OF MANGANESE.

Hitherto manganeſe has only been found in the ſtate of oxide. La Perouſe, indeed, ſuſpected that he had found it in a metallic ſtate: but probably there was ſome miſtake or other in his obſervations.

271 Oxide of manganeſe combined with barytes.

SPECIES 1. Oxide of manganeſe combined with barytes.

This ſpecies, which exiſts in great abundance in Romaneche near the river Soane in France, is found maſſive, forming a ſtratum in ſome places more than 12 feet thick.

Colour greyiſh black or browniſh black, of great intenſity. Luſtre, external, 0; internal, metallic, 1. Soon tarniſhes by expoſure to the air, and then becomes intenſely black. Texture granular. Fracture uneven; ſometimes conchoidal. Often porous. Hardneſs 11. Difficultly frangible. Sp. gr. from 3 950 to 4.10. Abſorbs water. When taken out of water after a minute's immerſion it has a ſtrong argillaceous ſmell. Conducts electricity nearly as well as if it were in a metallic ſtate. Infuſible by the blow-pipe. Tinges ſoda red; the colour diſappears before the blue cone of flame, and is reproduced by the action of the yellow flame.

From

(q) *Pott. Miſcelan. Berolens*, VI. 40.—*Margraff, Mem. Berlin*, 1773, p. 3.—*La Perouſe, Jour. de Phyſ.* XVI. 156. and XV. 67. and XXVIII. 68.—*Sage, Mem. Par.* 1785, 235.

Ores of Manganefe.

From the analyfis of Vauquelin, it appears that it is compofed of

50.0	white oxide of manganefe,
33.7	oxygen,
14.7	barytes,
1.2	filica,
.4	charcoal.
100.0 ¶	

¶ Dolomieu, Jour. de Min. N° xix 42.

SPECIES 2. Grey ore of manganefe *.

272 Grey ore of manganefe. * Kirwan, ii. 291.

This ore occurs both maffive and diffeminated: it is alfo fometimes cryftallized in flender four-fided prifms or needles.

Colour ufually dufky fteel grey; fometimes whitifh grey, or reddifh grey. Streak and powder black. External luftre 3 to 2; internal metallic, 2 to 1. Texture ftriated or foliated. Hardnefs 4 to 5. Brittle. Sp. gr. from 4.073 † to 4.8165 ‡. Before the blow-pipe darkens. Tinges borax reddifh brown.

† Vauquelin. ‡ Briffon.

A fpecimen of oxide of manganefe from the mountains of Vofges, which probably belonged to this fpecies, and which was analyfed by Vauquelin, was compofed of

82	oxide of manganefe,
7	carbonat of lime,
6	filica,
5	water.
100 §	

§ Jour. de Min. N° xvii. 13.

Sometimes it contains a little barytes and iron.

SPECIES 3. Black or brown ore of manganefe *.

273 Black or brown ore of manganefe. * Kirwan, ii. 292.—Wedgewood, Phil. Tranf. lxxiii. 284.

This ore is found fometimes in the ftate of powder, and fometimes indurated in amorphous maffes of various figures. Colour either black, fometimes with a fhade of blue or brown; or reddifh brown. Streak of the harder forts metallic; of the others, black. Luftre 0 to 1; internal (when it is indurated), metallic. Texture compact. Hardnefs 5 to 7. Sp. gr. 3.7076 to 3.9039; that of the powdery fometimes only 2. Before the blow-pipe it exhibits the fame phenomena as the laft fpecies.

A fpecimen of this ore, analyfed by Weftrum, contained

45.00	manganefe,
14.00	oxide of iron,
11.00	filica,
7.25	alumina,
2.00	lime,
1.50	oxide of copper,
18.00	air and water.
98.75	

GENUS II. SALTS OF MANGANESE.

274 G. II. Salts. Carbonat of manganefe. † Kirwan, ii. 297.

SPECIES 1. Carbonat of manganefe †.

White ore of manganefe.

This fpecies occurs in Sweden, Norway, and Tranffylvania. It is either in the form of loofe fcales, or maffive, or cryftallized in needles.

Colour white, or reddifh white. Texture either radiated or fcaly. Luftre of the fcaly 2. Tranfparency 1 to 2. Hardnefs of the maffive 6 to 9. Sp. gr. 2.794. Effervefces with mineral acids. Heated to rednefs, blackens. Tinges borax violet.

Metallic Ores.

SPECIES 2. Red ore of manganefe †.

Carbonat of manganefe and iron.

275 Red ore of manganefe. † Kirwan, ii. 297.—Napion, Mem. Turin, iv. 303.

This fpecies has been found in Piedmont and in the Pyrenees. It is fometimes in powder, fometimes maffive, fometimes cryftallized in rhomboidal prifms or needles.

Colour pale rofy red, mixed with white. Powder nearly white. Luftre 0. Tranfparency 1. Hardnefs 8. Sp. gr. 3.233. Effervefces with nitric and muriatic acids. When heated to rednefs becomes reddifh brown. Tinges borax red.

A fpecimen, analyfed by Ruprecht, contained

55.0	filica,
25.0	oxide of manganefe,
7.0	oxide of iron,
1.5	alumina.
98.5 §	

§ Jour de Phyf. xxxi. 22.

ORDER XVI. ORES OF TUNGSTEN.

As no eafy method has hitherto been difcovered of reducing tungften to a metallic ftate, we need not be furprifed that it has been applied to no ufe. Ores of tungften are by no means common. They have hitherto been found only in the primitive mountains. Their gangue is commonly quartz. They very often accompany tin ores.

GENUS I. OXIDES OF TUNGSTEN.

276 G. I. Oxides Wolfram.

SPECIES 1. Wolfram (R).

Oxides of tungften, iron, and *manganefe—Tungftat of iron* and *manganefe.*

This fpecies is found in different parts of Germany, in Sweden, Britain, France and Spain; and is almoft conftantly accompanied by ores of tin. It occurs both maffive and cryftallized. The primitive form of its cryftals, according to the obfervations of Mr Hauy, is a rectangular parallelopiped ‡, whofe length is 8.66, whofe breadth is 5, and thicknefs 4.33 *. It is not common, however, to find cryftals of this perfect form; in many cafes, the angles, and fometimes the edges, of the cryftal are wanting †; owing, as Mr Hauy has fhewn, to the fuperpofition of plates, whofe edges or angles decreafe according to a certain law ‡.

‡ Fig. 42. * Jour. de Min. N° xix. 8. † Fig. 43. ‡ Jour. de Min. N° xix. 8.

Colour brown or brownifh black. Streak reddifh brown. Powder ftains paper with the fame colour. Luftre external, 2; internal, 2 to 3; nearly metallic. Texture foliated. Eafily feparated into plates by percuffion. Hardnefs 6 to 8. Sp. gr. from 7.006 * to 7.333 †. Moderately electric by communication. Not magnetic. Infufible by the blow-pipe. Forms with borax a greenifh globule, and with microcofmic falt a tranfparent globule of a deep red ¶.

* Kirwan. † Hauy. ¶ Vauquelin, Jour. de Min. N° xix. 11.

The fpecimen of this ore, examined by Meffrs d'Elhuyart's, was compofed of

65	oxide of tungften,
22	oxide of manganefe,
13	oxide of iron.
100	

Another

(R) *Kirw.* II. 316.—*De Luyart, Mem. Thouloufe,* II. 141.—*Gmelin, Crell's Jour.* Englifh Tranf. III. 127, 205, and 293.—*La Peroufe, Jour. de Min.* N° IV. p. 23.

Ores of Molybdenum.

Another specimen from Pays le Mines in France, analysed by Vauquelin and Hecht, contained

67.00 oxide of tungsten,
18.00 black oxide of iron,
6.25 black oxide of manganese,
1.50 silica,
7.25 oxide of the iron and manganese.

100.00 §

§ *Vauquelin, Jour. de Min.* N° xix. 11.

GENUS II. SALTS OF TUNGSTEN.
SPECIES 1. Tungstat of lime (s).
Tungsten.

277 G. II. Salts. Tungstat of lime.

This ore, which is now exceedingly scarce, has hitherto been found only in Sweden and Germany. It is either massive or crystallized; and, according to Hauy, the primitive form of its crystals is the octahedron †.

† *Jour. de Min.* N° xxxiii. 657.

Colour yellowish white or grey. Lustre 3 to 2. Transparency 2 to 3. Texture foliated. Hardness 6 to 9. Sp. gr. 5.8 to 6.0665. Becomes yellow when digested with nitric or muriatic acids. Infusible by the blow-pipe. With borax forms a colourless glass, unless the borax exceed, and then it is brown. With microcosmic salt it forms a blue glass, which loses its colour by the yellow flame, but recovers it in the blue flame ‡.

‡ *Scheele* and *Bergman.*

It is composed of about 70 oxide of tungsten,
30 lime.
100

with a little silica and iron §.

§ *Scheele.*

278 Brown tungstat.

SPECIES 2. Brown Tungstat.

This ore is found in Cornwall, and is either massive or composed of small crystalline grains.

Colour grey, variegated with yellow and brown. Lustre 2, waxy. Hardness 6 to 7. Sp. gr. 5.57. Its powder becomes yellow when digested in aqua regia.

According to Klaproth, it is composed of

88.0 oxide of tungsten,
11.5 lime.

99.5

ORDER XVII. ORES OF MOLYBDENUM.

If ever molybdenum be found in abundance, it will probably be useful in dyeing and painting. At present it is very scarce, having only been found in Sweden, Germany, Carniola, and among the Alpes. Like tin and tungsten, it affects the primitive mountains.

279 G. I. Sulphuret. Common sulphuret.

GENUS I. SULPHURET OF MOLYBDENUM.
SPECIES 1. Common sulphuret (T).
Molybdena.

This ore, which is the only species of molybdenum ore at present known, is found commonly massive; sometimes, however, it is crystallized in hexahedral tables.

Colour light lead grey; sometimes with a shade of red. Streak bluish grey, metallic. Powder bluish. Lustre metallic, 3 to 2. Texture foliated. Lamellæ slightly flexible. Hardness 4. Sp. gr. 4.569 * to 4.7385 †. Feels greasy; stains the fingers. Marks bluish black. A piece of resin rubbed with this mineral becomes positively electric ‡. Insoluble in sulphuric and muriatic acids; but in a boiling heat colours them green. Effervesces with warm nitric acid, leaving a grey oxide undissolved. Before the blow-pipe, on a silver spoon, emits a white smoke, which condenses into a white powder, which becomes blue in the internal, and loses its colour in the external, flame. Scarcely affected by borax or microcosmic salt. Effervesces with soda, and gives it a reddish pearl colour.

* *Karsten.*
† *Brisson.*

Metallic Ores.

‡ *Hauy, Jour. de Min.* N° xix. 70.

Composed of about 60 molybdenum,
40 sulphur.

100 *

* *Klaproth.*

ORDER XVIII. ORES OF URANIUM.

Uranium has hitherto been found only in Germany, and has not been applied to any use. The only two mines where it has occurred are in the primitive mountains.

280 G. I. Oxides. Sulphuret of uranium.

GENUS I. OXIDES OF URANIUM.
SPECIES 1. Sulphuret of uranium †.
Pechblende.

† *Kirwan,* ii. 305.

This ore, which has been found at Johanngeorgenstadt in Saxony, and Joachimsthal in Bohemia, is either massive or stratified with other minerals.

Colour black or brownish black; sometimes with a shade of grey or blue. Streak darker. Powder opaque and black. Lustre semimetallic, from 3 to 1. Fracture conchoidal. Hardness 7 to 8. Very brittle. Sp. gr. from 6.3785 ‡ to 7.5, and even higher §. Imperfectly soluble in sulphuric and muriatic acids; perfectly in nitric acid and aqua regia. Solution wine yellow. Infusible with alkalies in a crucible: infusible by the blow-pipe *per se*. With borax and soda forms a grey opaque slag; with microcosmic salt, a green glass.

‡ *Morveau, Jour. de Min.* N° xxvii. 610.
§ *Klaproth, Beiträge,* ii. 197.

Composed of oxide of uranium and sulphur, and mixed with iron and silica, and sometimes lead.

A specimen of this ore from Joachimsthal, analysed lately by Klaproth, contained

86.5 uranium,
6.0 sulphuret of lead,
5.0 silica,
2.5 oxide of iron.

100.0 *

* *Beiträge,* ii. 221.

281 Yellow oxide of uranium.

SPECIES 2. Yellow oxide of uranium ‡.
Uranitic ochre.

‡ *Kirwan,* ii. 303.

This ore is generally found on the surface of the last species at Johanngeorgenstadt, and is either massive or in powder.

Colour yellow, red, or brown. Streak of the yellow sorts yellow; of the red, orange yellow. Lustre 0. Slightly stains the fingers. Feels meagre. Texture earthy. Hardness 3 to 4. Sp. gr. 3.2438 ‖. Infusible by the blow-pipe; but in a strong heat becomes brownish grey.

‖ *Hauy, Jour. de Min. ibid.*

Composed of oxide of uranium and oxide of iron.

(s) *Kirw.* II. 314.—*Scheele's Works* (French translation), II. 81.—*Bergman, ibid.* p. 94.—*Crell, Chem. Annalen.* 1784, 2 *Bard* 195.

(T) *Kirw.* II. 322.—*Scheele's Works* (French translation), I. 236.—*Pelletier, Jour. de Phys.* XXVII. 434.—*Ilsemann, ibid.* XXXIII. 292.—*Sage, ibid.* 339.—*Klaproth* and *Modeer, Ann. de Chim.* III. 120.

Genus II. Salts of Uranium.

281 G. II. Salts Carbonat of uranium.

Species 1. Carbonat of uranium ¶.

This ſubſtance is alſo found at Johanngeorgenſtadt, and near Eibenſtock and Rheinbreidenbach §. It is ſometimes amorphous, but more commonly cryſtallized. Its cryſtals are ſquare plates, octahedrons, and ſix ſided priſms.

¶ Kirwan, ii. 304.
§ Gmelin.

Colour green; ſometimes nearly white; ſometimes, though rarely, yellow. Streak greeniſh white. Luſtre 3 to 2; internal, 2; ſometimes pearly; ſometimes nearly metallic. Tranſparency 2 to 3. Texture foliated. Hardneſs 5 to 6. Brittle. Soluble in nitric acid without effervеſcence. Infuſible by alkalies.

Compoſed of carbonat of uranium, with ſome oxide of copper. When its colour is yellow it contains no copper.

Order XIX. Ores of Titanium.

Titanium has been known for ſo ſhort a time, and its properties are yet ſo imperfectly aſcertained, that many of its uſes muſt remain to be diſcovered. Its oxide, as we learn from Mr Darcet, has been employed in painting on porcelain *. Hitherto it has been found only in the primitive mountains, the Crapacks †, the Alpes (u), and the Pyrenees ‡. It has been found alſo in Brittany ‖ and in Cornwal.

* Jour. de Min. N° xv. 27.
† Ibid. N° xii. 51.
‡ Jour. de Min. N° xxxii. 614.
‖ Ibid.

Genus I. Oxides of Titanium.

283 G. I. Oxides. Red oxide of titanium.

Species 1. Red oxide of Titanium.

Red ſhorl—Sagenite.

This ore has been found in Hungary, the Pyrenees, the Alpes, and in Brittany in France. It is generally cryſtallized. The primitive form of its cryſtals, according to the obſervations of Mr Hauy, is a rectangular priſm, whoſe baſe is a ſquare; and the form of its molecules is a triangular priſm, whoſe baſe is a right angled iſoſceles triangle, and the height is to any of the ſides of the baſe about the right angle as $\sqrt{12}$ to $\sqrt{5}$, or nearly as 3 : 2 ¶. Sometimes the cryſtals of titanium are ſix-ſided, and ſometimes four-ſided, priſms, and often they are implicated together ‡.

¶ Jour. de Min. N° xv. 28. and xxxii. 615.
‡ Fig. 44.

Colour red or browniſh red. Powder brick or orange red. Luſtre 3. Tranſparency commonly 0; ſometimes 1. Texture foliated. Hardneſs 9. Brittle. Sp. gr. from 4.18 * to 4.2469 †. Not affected by the mineral acids. When fuſed with carbonat of potaſs, and diluted with water, a white powder precipitates, heavier than the titanium employed. Before the blow-pipe it does not melt, but becomes opaque and brown. With microcoſmic ſalt it forms a globule of glaſs, which appears black; but its fragments are violet. With borax it forms a deep yellow glaſs, with a tint of brown. With ſoda it divides and mixes, but does not form a tranſparent glaſs.

* Klaproth.
† Vauquelin and Hecht.

When pure, it is compoſed entirely of oxide of titanium.

284 Menachanite.

Species 2. Menachanite (x).

Oxide of titanium combined with iron.

This ſubſtance has been found abundantly in the valley of Menachan in Cornwal; and hence was called menachanite by Mr Gregor, the diſcoverer of it. It is in ſmall grains, like gunpowder, of no determinate ſhape, and mixed with a fine grey ſand. Colour black. Eaſily pulverized. Powder attracted by the magnet. Sp. gr. 4.427. Does not detonate with nitre. With two parts of fixed alkali it melts into an olive coloured maſs, from which nitric acid precipitates a white powder. The mineral acids only extract from it a little iron. Diluted ſulphuric acid, mixed with the powder, in ſuch a proportion that the maſs is not too liquid, and then evaporated to dryneſs, produces a blue coloured maſs. Before the blow-pipe does not decrepitate nor melt. It tinges microcoſmic ſalt green; but the colour becomes brown on cooling: yet microcoſmic ſalt does not diſſolve it. Soluble in borax, and alters its colour in the ſame manner.

Metallic ores.

According to the analyſis of Mr Gregor, it is compoſed of

46	oxide of iron,
45	oxide of titanium.
91	with ſome ſilica and mangaueſe †.

† M. Gregor.

According to Mr Klaproth's analyſis, it is compoſed of

51.00	oxide of iron,
45.25	oxide of titanium,
3.50	ſilica,
.25	oxide of mangancſe.
100.00 ‡	

Jour. de Phyſ. xxxix. 72. 152.
‡ Beiträge, ii. 231.

A mineral, nearly of the ſame nature with the one juſt deſcribed, has been found in Bavaria. Its ſpecific gravity, however, is only 3.7. According to the analyſis of Vauquelin and Hecht, it is compoſed of

49	oxide of titanium,
35	iron,
2	manganeſe,
14	oxygen combined with the iron and manganeſe.
100 §	

§ Jour. de Min. N° xix. 57.

285 Calcareo-ſiliceous ore of titanium.

Species 3. Calcareo-ſiliceous ore of titanium.

Oxide of titanium combined with lime and ſilica—Titanite †.

This ore has hitherto been found only near Paſſau. It was diſcovered by Profeſſor Hunger. It is ſometimes maſſive, but more commonly cryſtallized in four-ſided priſms, not longer than one fourth of an inch.

† Kirwan, ii. 331.

Colour reddiſh, yellowiſh, or blackiſh brown; ſometimes whitiſh grey. Powder whitiſh grey. Luſtre waxy or nearly metallic, 2 to 3. Tranſparency from 0 to 2. Texture foliated. Hardneſs 9 or more. Brittle. Sp. gr. 3.510. Muriatic acid, by repeated digeſtion, diſſolves one-third of it. Ammonia precipitates from this ſolution a clammy yellowiſh ſubſtance. Infuſible by the blow pipe, and alſo in a clay crucible; but in charcoal is converted into a black opaque porous ſlag.

According to the analyſis of Klaproth, it is compoſed of

33	oxide of titanium,
35	ſilica,
33	lime.
101	

Order

(u) *Dolom eu, Jour. de Min.* N° XLII. 431. and *Sauſſure, Voyages*, N° 1894.

(x) *Kirw.* II. 326.—*Gregor, Jour. de Phyſ.* XXXIX. 72. and 152.—*Schmeiſſer, Crell's Annals* (Engliſh tranſlation), III. 252.

Ores of Tellurium.

Order XX. ORES OF TELLURIUM.

Hitherto tellurium has only been found in Transylvania. It occurs in three different mines; that of Fatzbay, Offenbanya, and Nagyag, which are considered as gold mines. becaufe they contain lefs or more of that metal. Its gangue is commonly quartz.

286 G. I. Alloys. White gold ore of Fatzbay.

Genus I. alloys of tellurium.

species 1. White gold ore of Fatzbay.

Alloy of tellurium and iron, with fome gold.

This fpecies is generally maffive. Its colour is between tin white and lead grey. Luftre confiderable, metallic. Texture granular *.

According to Klaproth's analyfis, it is compofed of

72.0 iron,
25.5 tellurium,
2.5 gold.

100.0 †

287 Graphic gloden ore of Offenbanya.

species 2. Graphic golden ore of Offenbanya.

Tellurium alloyed with gold and filver.

This ore is compofed of flat prifmatic cryftals; the arrangement of which has fome refemblance to Turkifh letters. Hence the name of the ore.

Colour tin white, with a tinge of brafs yellow ‡. Luftre metallic, 3, Hardnefs 4 to 5. Brittle. Sp. gr. 5.723. Before the blow pipe decrepitates, and melts like lead. Burns with a lively brown flame and difagreeable fmell, and at laft vanifhes in a white fmoke, leaving only a whitifh earth ||.

According to Klaproth's analyfis it is compofed of

60 tellurium,
30 gold,
10 filver.

100 §

The yellow gold ore of Nagyag would belong to this fpecies were it not that it contains lead. Its compofition, according to Klaproth's anaylfis, is as follows:

45.0 tellurium,
27.0 gold,
19.5 lead,
8.5 filver,

100.0 and an atom of fulphur *.

288 Grey foliated gold ore of Nagyag.

species 3. Grey foliated gold ore of Nagyag.

This ore is found in plates, of different degrees of thicknefs, adhering to one another, but eafily feparable: thefe are fometimes hexahedral, and often accumulated fo as to leave cells between them.

Colour deep lead grey, paffing to iron black, fpotted. Luftre metallic, moderate. Texture foliated; leaves flightly flexible †. Hardnefs 6. Sp. gr. 8.919. Stains the fingers. Soluble in acids with effervefcence ‡.

According to Klaproth, it is compofed of

50.0 lead,
33.0 tellurium,
8.5 gold,
7.5 fulphur,
1.0 filver and copper.

100.0 §

* Ann de Chim. xxv. 327.
† Ibid. 280.
‡ Ann. de Chim. xxv. 328.
|| De Born, Kirwan's Min. ii. 110.
§ Ann. de Chim. xxv. 280.
* Ibid.
† Klaproth, Ann. de Chim. xxv. 329.
‡ De Born, Kirwan's Min. ii. 99.
§ Ann. de Chim. ibid. 280.

Metallic Ores.

Order XXI. ORES OF CHROMUM.

Chromum has hitherto been found in too fmall quantities for its extenfive application to the arts. Whenever it becomes plentiful, its properties will render it of great importance both to the dyer and painter. Nature has ufed it to colour fome of her moft beautiful mineral productions: And can art copy after a better model? Hitherto it has been found only in two places, near Ekaterinbourg in Siberia, and in the department of the Var in France. In the firft of thefe places, and probably alfo in the fecond, its gangue is quartz.

289 G. I. Salts. Chromat of lead.

Genus I. salts of chromum.

species 1. Chromat of lead.

Red lead ore of Siberia.

This fingular mineral, which has now become fcarce, is found in the gold mines of Berefof near Ekaterimbourg in Siberia, cryftallized in four fided prifms, fometimes terminated by four-fided pyramids, fometimes not.

Colour red, with a fhade of yellow. Streak and powder a beautiful orange yellow. Luftre from 2 to 3. Tranfparency 2 to 3. Structure foliated. Texture compact. Fracture uneven. Hardnefs 5 to 4. Sp. gr. 6.0269 † to 5.75 ‡. Does not effervefce with acids. Before the blow pipe decrepitates; fome lead is reduced, and the mineral is converted to a black flag, which tinges borax green.

According to the analyfis of Vauquelin, it is compofed of

65.12 oxide of lead,
34.88 chromic acid.

100.00 ||.

species 2. Chromat of iron.

290 Chromat of iron.

This mineral, which has been found only near Gaffin in the department of Var in France, is in irregular meffas.

Colour brown, not unlike that of brown blende. Luftre metallic. Hardnefs moderate. Sp. gr. 4.0326. Melts with difficulty before the blow-pipe; to borax it communicates a dirty green. Infoluble in nitric acid. Melted with potafs, and diffolved in water, the folution affumes a beautiful orange yellow colour.

It is compofed of 63.6 chromic acid,
36.0 oxide of iron.

99.6 †

† Briffon.
‡ Bindheim.
|| Jour. de Min. N° xxxiv. 760.
† Taffaert, Ann. de Chim. xxxi. 220.

Chap. V. Of the Chemical Analysis of Minerals.

291 Analyfis of minerals.

The progrefs which the art of analyfing minerals has made within thefe laft twenty years is truly aftonifhing. To feparate five or fix fubftances intimately combined together, to exhibit each of them feparately, to afcertain the precife quantity of each, and even to detect the prefence and the weight of fubftances which do not approach $\frac{1}{100}$th part of the compound, would, at no very remote period, have been confidered as a hopelefs, if not an impoffible, tafk; yet this can now be done with the moft rigid accuracy.

292 Begun by Margraff.

The firft perfon who undertook the analyfis of minerals was Margraff of Berlin. His attempts were indeed rude; but their importance was foon perceived by other chemifts, particularly by Bergman and Scheele, whofe whoſe induſtry and addreſs brought the art of analyſing minerals to a conſiderable degree of perfection.

But their methods, though they had very conſiderable merit, and, conſidering the ſtate of the ſcience, are wonderful proofs of the genius of the inventors, were often tedious and uncertain, and could not in all caſes be applied with confidence. Theſe defects were perceived by Mr Klaproth of Berlin, who applied himſelf to the analyſis of minerals with a perſevering induſtry which nothing could fatigue, and an ingenuity and accuracy which nothing could perplex. He corrected what was wrong, and ſupplied what was wanting, in the analytical method; invented new proceſſes, diſcovered new inſtruments; and it is to his labours, more than to thoſe of any other chemiſt, that the degree of perfection, to which the analyſis of minerals has attained, is to be aſcribed.

293 Improved by Klaproth

Many improvements, however, were introduced by other chemiſts, eſpecially by Mr Vauquelin, whoſe analyſes in point of accuracy and ingenuity rival thoſe of Klaproth himſelf.

294 And other chemiſts.

We ſhall, in this chapter, give a ſhort deſcription of the moſt perfect method of analyſing minerals, as far as we are acquainted with it. We ſhall divide the chapter into four ſections. In the firſt, we ſhall give an account of the inſtruments uſed in analyſes; in the ſecond, we ſhall treat of the method of analyſing ſtones; in the third, of analyſing combuſtibles; and in the fourth, of the analyſes of ores.

Sect. I. *Of the Inſtruments of Analyſes.*

295 Method of obtaining chemical agents pure.

I. The chymical agents, by means of which the analyſis of minerals is accompliſhed, ought to be prepared with the greateſt care, becauſe upon their purity the exactneſs of the operation entirely depends. Theſe agents are the three alkalies, both pure and combined with carbonic acid; the ſulphuric, nitric, and muriatic acids; hydroſulphuret of potaſs and ſulphurated hydrogen gas diſſolved in water; pruſſic alkali, and a few neutral ſalts.

1. Potaſs and ſoda may be obtained pure, either by means of alcohol, or by the method deſcribed in the article Chemistry, n° 372. *Suppl.* Theſe alkalies are known to be pure when their ſolution in pure water occaſions no precipitate in lime and barytic water; when the precipitate which it produces in a ſolution of ſilver is completely diſſolved by nitric acid; and, laſtly, when ſaturated with carbonic acid it depoſits no ſilica.

2. Ammonia is procured by diſtilling one part of muriat of ammonia with two parts of quicklime, and receiving the gas in a diſh containing a quantity of pure water, equal in weight to the muriat employed. Its purity is known by the ſame teſts which aſcertain the purity of fixed alkalies.

3. The carbonats of potaſs and ſoda may be formed by diſſolving the potaſs and ſoda of commerce in pure water, ſaturating the ſolution with carbonic acid, and cryſtallizing them repeatedly. When pure, theſe cryſtals effloreſce in the air; and the precipitate which they occaſion in ſolutions of barytes and of ſilver is completely ſoluble in nitric acid. Carbonat of ammonia is obtained by diſtilling together one part of muriat of ammonia and two parts of carbonat of lime.

4. The ſulphuric acid of commerce often contains nitric acid, potaſs, lead &c. It may be purified by diſtillation in a low cucurbite. The firſt portion, when it comes over, muſt be ſet aſide; it contains the nitric acid. The other impurities remain behind in the cucurbite. Sulphuric acid, when pure, diſſolves indigo without altering its colour, does not attack mercury while cold, and cauſes no precipitate in pure alkaline ſolutions.

5. Nitric acid often contains both ſulphuric and muriatic acids. It is eaſily purified by throwing into it about three parts of litharge in fine powder for every 100 parts of the acid, allowing the mixture to remain for 24 hours, ſhaking it occaſionally, and then diſtilling it. The ſulphuric and muriatic acids combine with the lead, and remain behind in the retort. Pure nitric acid occaſions no precipitate in the ſolutions of barytes and ſilver.

6. The muriatic acid of commerce uſually contains ſulphuric acid, oxymuriatic acid, and oxide of iron. It may be purified by diſtillation with a little muriat of ſoda; taking care to ſet aſide the firſt portion which comes over. When pure it cauſes no precipitate in the ſolution of barytes, nor of pure alkalies, and does not attack mercury while cold.

7. Hydroſulphuret of potaſs is made by ſaturating a ſolution of pure potaſs with ſulphurated hydrogen gas; and water may be ſaturated with ſulphurated hydrogen gas in the ſame manner. See Chemistry, n° 857. *Suppl.*

8. The method of preparing pruſſic alkali, oxalic acid, and the other ſubſtances uſed in analyſes, has been already deſcribed in the article Chemistry, *Suppl.* it is unneceſſary therefore to repeat it here.

296 How to reduce the mineral to powder.

II. Before a mineral is ſubmitted to analyſis, it ought to be reduced to an impalpable powder. This is by no means an eaſy taſk when the ſtone is extremely hard. It ought to be raiſed to a bright red or white heat in a crucible, and then inſtantly thrown into cold water. This ſudden tranſition makes it crack and break into pieces. If theſe pieces are not ſmall enough, the operation may be repeated on each till they are reduced to the proper ſize. Theſe fragments are then to be beaten to ſmall pieces in a poliſhed ſteel mortar; the cavity of which ſhould be cylindrical, and the ſteel peſtle ſhould fit it exactly, in order to prevent any of the ſtone from eſcaping during the act of pounding. As ſoon as the ſtone is reduced to pretty ſmall pieces, it ought to be put into a mortar of rock cryſtal or flint, and reduced to a coarſe powder. This mortar ſhould be about four inches in diameter, and rather more than an inch in depth. The peſtle ſhould be formed of the ſame ſtone with the mortar, and care ſhould be taken to know exactly the ingredients of which this mortar is compoſed. Klaproth's mortar is of flint. We have given its analyſis in n° 32. of this article.

When the ſtone has been reduced to a coarſe powder, a certain quantity, whoſe weight is known exactly, 100 grains for inſtance, ought to be taken and reduced to as fine a powder as poſſible. This is beſt done by pounding ſmall quantities of it at once, not exceeding 10 grains. The powder is as fine as poſſible when it feels ſoft, adheres together, and as it were forms a cake under the peſtle. It ought then to be weighed exactly. It will almoſt always be found heavier after being pounded than it was before; owing to a certain quantity of the ſubſtance of the mortar which has been rubbed off during the grinding and mixed with the powder.

Analysis of Minerals. der. This additional weight must be carefully noted; and after the analysis, a portion of the ingredients of the mortar, corresponding to it, must be subtracted.

297 Chemical dishes. III. It is necessary to have a crucible of pure silver, or, what is far preferable, of platinum, capable of holding rather more than seven cubic inches of water, and provided with a cover of the same metal. There should also be ready a spatula of the same metal about four inches long.

The dishes in which the solutions, evaporations, &c. are performed, ought to be of glass or porcelain. Those of porcelain are cheaper, because they are not so apt to break. Those which Mr Vauquelin uses are of porcelain; they are sections of spheres, and are glazed both within and without, except that part of the bottom which is immediately exposed to the fire.

Sect. II. *Analysis of Stones* (y).

298 Ingredients of stones. The only substances which enter into the composition of the simple stones, as far at least as analysis has discovered, are the six earths, silica, alumina, zirconia, glucina, lime, and magnesia; and the oxides of iron, manganese, nickel, chromum, and copper (z). Seldom more than four or five of these substances are found combined together in the same stone: we shall suppose, however, in order to prevent unnecessary repetitions, that they are all contained in the mineral which we are going to analyse.

299 Method of decomposing stones. Let 100 or 200 grains of the stone to be analysed, previously reduced to a fine powder, be mixed with three times its weight of pure potass and a little water, and exposed in the silver or platinum crucible to a strong heat. The heat should at first be applied slowly, and the matter should be constantly stirred, to prevent the potass from swelling and throwing any part out of the crucible. When the whole water is evaporated, the mixture should be kept for half an hour or three quarters in a strong red heat.

If the matter in the crucible melts completely, and appears as liquid as water, we may be certain that the stone which we are analysing consists chiefly of silica; if it remains opaque, and of the consistence of paste, the other earths are most abundant; if it remains in the form of a powder, alumina is the prevalent earth. If the matter in the crucible be of a dark or brownish red colour, it contains oxide of iron; if it is grass green, manganese is present; if it is yellowish green, it contains chromum.

When the crucible has been taken from the fire and wiped on the outside, it is to be placed in a capsule of porcelain, and filled with water. This water is to be renewed from time to time till all the matter is detached from the crucible. The water dissolves a part of the combination of the alkali with the silica and alumina of the stone; and if a sufficient quantity were used, it would dissolve the whole of that combination.

Muriatic acid is now to be poured in till the whole of the matter is dissolved. At first a flaky precipitate appears, because the acid combines with the alkali which kept it in solution. Then an effervescence takes place, owing to the decomposition of some carbonat of potass formed during the fusion. At the same time the flaky precipitate is redissolved; as is also that part of the matter which, not having been dissolved in the water, had remained at the bottom of the dish in the form of a powder. This powder, if it consists only of silica and alumina, dissolves without effervescence; but if it contains lime, an effervescence takes place.

If this solution in muriatic acid be colourless, we may conclude that it contains no metallic oxide, or only a very small portion; if its colour be purplish red, it contains manganese; orange red indicates the presence of iron; and golden yellow the presence of chromum.

This solution is to be poured into a capsule of porcelain, covered with paper, and evaporated to dryness in a sand bath. When the evaporation is drawing towards its completion, the liquor assumes the form of jelly. It must then be stirred constantly with a glass or porcelain rod, in order to facilitate the disengagement of the acid and water, and to prevent one part of the matter from being too much, and another not sufficiently dried. Without this precaution, the silica and alumina would not be completely seperated from each other. 300

How the silica is separated. When the matter is reduced almost to a dry powder, a large quantity of pure water is to be poured on it; and, after exposure to a slight heat, the whole is to be poured on a filter. The powder which remains upon the filter is to be washed repeatedly, till the water with which it has been washed ceases to precipitate silver from its solutions. This powder is the whole of the *silica* which the stone that we are analysing contained. It must first be dried between folds of blotting paper, then heated red hot in a platinum or silver crucible, and weighed while it is yet warm. It ought to be a fine powder, of a white colour, not adhering to the fingers, and entirely soluble in acids. If it be coloured, it is contaminated with some metallic oxide; and shews, that the evaporation to dryness has been performed at too high a temperature. To separate this oxide, the silica must be boiled with an acid, and then washed and dried as before. The acid solution must be added to the water which passed through the filter, and which we shall denominate A.

The watery solution A is to be evaporated till its quantity does not exceed 30 cubic inches, or nearly an English pint. A solution of carbonat of potass is then to be poured into it till no more matter precipitates. It ought to be boiled a few moments to enable all the precipitate to fall to the bottom. When the whole of the precipitate has collected at the bottom, the supernatant liquid is to be decanted off; and water being substituted in its place, the precipitate and water are to be thrown upon a filter. When the water has run off, the filter with the precipitate upon it is to be placed between folds of blotting paper. When the precipitate has acquired some consistence, it is to be carefully collected by an ivory knife, mixed with a solution of pure potass, and boiled in a porcelain capsule. If any alumina

(y) Part of this section is to be considered as an abstract of a treatise of Vauquelin on the analysis of stones, published in the *Annales de Chimie*, Vol. XXX. p. 66.

(z) Barytes has also been discovered in one single stone, the *staurolite*; but its presence in stones is so uncommon, that it can scarcely be looked for. The method of detecting it shall be noticed afterwards.

Analyſis of Minerals. alumina or glucina be preſent, they will be diſſolved in the potaſs; while the other ſubſtances remain untouched in the form of a powder, which we ſhall call B.

301 And the alumina, Into the ſolution of potaſs as much acid muſt be poured as will not only ſaturate the potaſs, but alſo completely rediſſolve any precipitate which may have at firſt appeared. Carbonat of ammonia is now to be added in ſuch quantity that the liquid ſhall taſte of it. By this addition the whole of the alumina will be precipitated in white flakes, and the glucina will remain diſſolved, provided the quantity of carbonat of ammonia uſed be not too ſmall. The liquid is now to be filtered, and the alumina which will remain on the filter is to be waſhed, dried, heated red hot, and then weighed. To ſee if it be really alumina, diſſolve it in ſulphuric acid, and add a ſufficient quantity of ſulphat or acetite of potaſs; if it be alumina, the whole of it will be converted into cryſtals of alum.

302 Glucina, Let the liquid which has paſſed through the filter be boiled for ſome time, and the glucina, if it contains any, will be precipitated in a light powder, which may be dried and weighed. When pure, it is a fine, ſoft, very light, taſteleſs powder, which does not concrete when heated, as alumina does.

303 Lime, The reſiduum B may contain lime, magneſia, and one or more metallic oxides. Let it be diſſolved in weak ſulphuric acid, and the ſolution evaporated to dryneſs. Pour a ſmall quantity of water on it. The water will diſſolve the ſulphat of magneſia, and the metallic ſulphats; but the ſulphat of lime will remain undiſſolved. Let it be heated red hot in a crucible, and weighed. The lime amounts to 0.41 of the weight.

Let the ſolution containing the remaining ſulphats be diluted with a large quantity of water, let a ſmall exceſs of acid be added, and then let a ſaturated carbonat of potaſs be poured in. The oxides of chromum, iron, and nickel, will be precipitated, and the magneſia and oxide of manganeſe will remain diſſolved. The precipitate we ſhall call C.

304 Manganeſe, Into the ſolution let a ſolution of hydroſulphuret of potaſs be poured, and the mangancſe will be precipitated in the ſtate of a hydroſulphuret. Let it be calcined in contact with air, and weighed. The magneſia

305 Magneſia, may then be precipitated by pure potaſs, waſhed, expoſed to a red heat, and then weighed.

Let the reſiduum C be boiled repeatedly with nitric acid, then mixed with pure potaſs; and after being

306 Chromum, heated, let the liquid be decanted off. Let the precipitate, which conſiſts of the oxides of iron and nickel, be waſhed with pure water; and let this water be added to the ſolution of the nitric acid and potaſs. That ſolution contains the chromum converted into an acid. Add to this ſolution an exceſs of muriatic acid, and evaporate till the liquid aſſumes a green colour; then add a pure alkali: The chromum precipitates in the ſtate of an oxide, and may be dried, and weighed.

307 Iron, Let the precipitate, conſiſting of the oxides of iron and nickel, be diſſolved in muriatic acid; add an exceſs of ammonia: the oxide of iron precipitates. Let it be waſhed, dried, and weighed.

308 And nickel. Evaporate the ſolution, and the oxide of nickel will alſo precipitate; and its weight may be aſcertained in the ſame manner with the other ingredients.

The weights of all the ingredients obtained are now to be added together, and their ſum-total compared with the weight of the matter ſubmitted to analyſis. If the Analyſis of Minerals.
two are equal, or if they differ only by .03 or .04 parts, we may conclude that the analyſis has been properly performed: but if the loſs of weight be conſiderable, ſomething or other has been loſt. The analyſis muſt therefore be repeated with all poſſible care. If there is ſtill the ſame loſs of weight, we may conclude that the ſtone contains ſome ſubſtance, which has either evaporated by the heat, or is ſoluble in water.

309 A freſh portion of the ſtone muſt therefore be broken into ſmall pieces, and expoſed in a porcelain crucible to a ſtrong heat. If it contains water, or any other volatile ſubſtance, they will come over into the receiver; and their nature and weight may be aſcertained. Method of detecting volatile bodies.

If nothing comes over into the receiver, or if what comes over is not equal to the weight wanting, we may conclude that the ſtone contains ſome ingredient which is ſoluble in water.

310 To diſcover whether it contains *potaſs*, let the ſtone, reduced to an impalpable powder, be boiled five or ſix times in ſucceſſion, with very ſtrong ſulphuric acid, applying a pretty ſtrong heat towards the end of the operation, in order to expel the exceſs of acid; but taking care that it be not ſtrong enough to decompoſe the ſalts which have been formed. Method of aſcertaining whether ſtones contain potaſs

Water is now to be poured on, and the reſiduum, which does not diſſolve, is to be waſhed with water till it becomes taſteleſs. The watery ſolution is to be filtered, and evaporated to dryneſs, in order to drive off any exceſs of acid which may be preſent. The ſalts are to be again diſſolved in water; and the ſolution, after being boiled for a few moments, is to be filtered and evaporated to a conſiſtence proper for cryſtallizing. If the ſtone contains a ſufficient quantity of alumina, and if potaſs be preſent, cryſtals of alum will be formed; and the quantity of potaſs may be diſcovered by weighing them, it being nearly $\frac{1}{10}$th of their weight. If the ſtone does not contain alumina, or not in ſufficient quantity, a ſolution of pure alumina in ſulphuric acid muſt be added. Sometimes the alum, even when potaſs is preſent, does not appear for ſeveral days, or even weeks; and ſometimes, when a great quantity of alumina is preſent, if the ſolution has been too much concentrated by evaporation, the ſulphat of alumina prevents the alum from cryſtallizing at all. Care, therefore, muſt be taken to prevent this laſt ſource of error. The alum obtained may be diſſolved in water, and barytic water poured into it as long as any precipitate forms. The liquor is to be filtered, and evaporated to dryneſs. The reſiduum will conſiſt of potaſs and a little carbonat of potaſs. The potaſs may be diſſolved in a little water. This ſolution, evaporated to dryneſs, gives us the potaſs pure; which may be examined and weighed.

311 If no cryſtals of alum can be obtained, we muſt look Or ſoda.
for ſome other ſubſtance than potaſs. The ſtone, for inſtance, may contain ſoda. The preſence of this alkali may be diſcovered by decompoſing the ſolution in ſulphuric acid, already deſcribed, by means of ammonia. The liquid which remains is to be evaporated to dryneſs, and the reſiduum is to be calcined in a crucible. By this method, the ſulphat of ammonia will be volatilized, and the ſoda will remain. It may be rediſſolved in water, cryſtallized, and examined.

If ſulphuric acid does not attack the ſtone, as is often the caſe, it muſt be decompoſed by fuſion with ſoda, Analysis of Minerals. da, in the same manner as formerly directed with potass. The matter, after fusion, is to be diluted with water, and then saturated with sulphuric acid. The solution is to be evaporated to dryness, the residuum again dissolved in water, and evaporated. Sulphat of soda will crystallize first; and by a second evaporation, if the stone contains potass and alumina, crystals of alum will be deposited.

The presence of potass may be discovered, by mixing with a somewhat concentrated solution of muriat of platinum, the salt obtained, either by decomposing the stone immediately by an acid, or by saturating with an acid the matter obtained by fusing the stone with soda. If any potass be present, a very red precipitate will be formed. This precipitate is a triple salt, composed of potass, muriatic acid, and oxide of platinum. Ammonia, indeed, produces the same precipitate; but ammonia has not hitherto been discovered in stones.

312 Analysis of saline stones, In this manner may simple stones and aggregates be analysed. As to saline stones, their analysis must vary according to the acid which they contain. But almost all of them may be decomposed by one or other of two methods; of each of which we shall give an example.

I. Analysis of Carbonat of Strontites.

313 Of Carbonats, Klaproth analysed this mineral by dissolving 100 parts of it in diluted muriatic acid: during the solution, 30 parts of carbonic acid escaped. The solution crystallized in needles, and when dissolved in alcohol, burnt with a purple flame. Therefore it contained strontites. He dissolved a grain of sulphat of potass in six ounces of water, and let fall into it three drops of the muriatic solution. No precipitate appeared till next day. Therefore the solution contained no barytes; for if it had, a precipitate would have appeared immediately.

He then decomposed the muriatic acid solution, by mixing it with carbonat of potass. Carbonat of strontites precipitated. By the application of a strong heat, the carbonic acid was driven off. The whole of the earth which remained was dissolved in water. It crystallized; and when dried, weighed $69\frac{1}{2}$ *.

* *Klaproth's Beiträge*, i. 260.

II. Analysis of Sulphat of Strontites.

Mr Vauquelin analysed an impure specimen of this mineral as follows:

314 Sulphats, On 200 parts of the mineral, diluted nitric acid was poured. A violent effervescence took place, and part of the mineral was dissolved. The undissolved portion, after being heated red hot, weighed 167. Therefore 33 parts were dissolved.

The nitric solution was evaporated to dryness: A reddish substance remained, which indicated the presence of oxide of iron. This substance was redissolved in water, and some ammonia mixed with it; a reddish precipitate appeared, which, when dried, weighed 1, and was oxide of iron. The remainder of the solution was precipitated by carbonat of potass. The precipitate weighed, when dried, 20, and possessed the properties of carbonat of lime. Therefore 200 parts of this mineral contain 20 of carbonat of lime, 1 of oxide of iron, and the remainder of the 33 parts he concluded to be water.

The 167 parts, which were insoluble in nitric acid, were mixed with 500 parts of carbonat of potass, and 7000 parts of water, and boiled for a considerable time. The solution was then filtered, and the residuum washed and dried. The liquid scarcely effervesced with acids; but with barytes it produced a copious precipitate, totally indissoluble in muriatic acid. Therefore it contained sulphuric acid.

The undissolved residuum, when dried, weighed 129 parts. It dissolved completely in muriatic acid. The solution crystallized in needles; when dissolved in alcohol, it burnt with a purple flame; and, in short, had all the properties of muriat of strontites. Therefore these 129 parts were carbonat of strontites. Now, 100 parts of this carbonat contain 30 of carbonic acid; therefore 129 contain 38.7. Therefore the mineral must contain in 200 parts 90.3 of strontites.

Now, the insoluble residuum of 167 parts was pure sulphat of strontites; and we have seen that it contained 90.3 of strontites. Therefore the sulphuric acid must amount to 76.7 parts *.

* *Jour. de Min* N° xxxvii. p. 1.

Nearly in the same manner as in the first of these examples may the analysis of carbonat of lime and barytes be performed; and nearly in the same manner with the second, we may analyse the sulphats of lime and barytes.

Phosphats, 315 Phosphat of lime may be dissolved in muriatic acid, and the lime precipitated by sulphuric acid, and its quantity ascertained by decomposing the sulphat of lime obtained. The liquid solution may be evaporated to the consistence of honey, mixed with charcoal powder, and distilled in a strong heat. By this means phosphorus will be obtained. The impurities with which the phosphat may be contaminated will partly remain undissolved, and be partly dissolved, in muriatic acid. They may be detected and ascertained by the rules laid down in the second section of this chapter.

Fluats, 316 The fluat of lime may be mixed with sulphuric acid and distilled. The fluoric acid will come over in the form of gas, and its weight may be ascertained. What remains in the retort, which will consist chiefly of sulphat of lime, may be analysed by the rules already laid down.

And borats. 317 The borat of lime may be dissolved in nitric or sulphuric acid. The solution may be evaporated to dryness, and the boracic acid separated from the residuum by means of alcohol, which will dissolve it without acting on any of the other ingredients. The remainder of the dry mass may be analysed by the rules laid down in Sect. II. of this Chapter.

Sect. III. *Of the Analysis of Combustibles.*

The only combustibles of whose analysis it will be necessary to speak are coals and sulphur; for the method of analysing the diamond and oil has already been given in the article Chemistry, *Suppl.*

Earths of coal how examined. 318 Coal is composed of carbon, bitumen, and some portion of earth. The earths may be detected by burning completely a portion of the coal to be analysed. The ashes which remain after incineration consist of the earthy part. Their nature may be ascertained by the rules laid down in Sect. II. of this Chapter.

For the method of ascertaining the proportion of carbon and bitumen in coal, we are indebted to Mr Kirwan.

Method of detecting the relative proportions of charcoal and bitumen. 319 When nitre is heated red hot, and charcoal is thrown on it, a violent detonation takes place; and if the quantity of charcoal be sufficient, the nitre is completely decomposed. Now, it requires a certain quantity of pure carbon

Analyfis of Minerals.

carbon to decompofe a given weight of nitre. From the experiments of Lavoifier, it follows that, when the detonation is performed in clofe veffels under water, 13.21 parts of charcoal are capable of decompofing 100 parts of nitre *. But when the detonation is performed in an open crucible, a fmaller proportion of charcoal is neceffary, becaufe part of the nitre is decompofed by the action of the furrounding air. Scheele found that under thefe circumftances 10 parts of plumbago were fufficient to decompofe 96 parts of nitre, and Mr Kirwan found that nearly the fame quantity of charcoal was fufficient for producing the fame effect.

* *Mem. Sçav. Etrang.* xi. 610.

Macquer long ago obferved, that no volatile oily matter will detonate with nitre, unlefs it be previoufly reduced to a charcoal; and that then its effect upon nitre is precifely proportional to the charcoal which it contains †. Mr Kirwan, upon trying the experiment with *vegetable pitch* and *maltha*, found that thefe fubftances did not detonate with nitre, but merely burn upon its furface with a white or yellow flame; and that after they were confumed, nearly the fame quantity of charcoal was neceffary to decompofe the nitre which would have been required if no bitumen had been ufed at all ‡. Now coals are chiefly compofed of charcoal and bitumen. It occurred therefore to Mr Kirwan, that the quantity of charcoal which any coal contains may be afcertained by detonating it with nitre: For fince the bitumen of the coal has no effect in decompofing nitre, it is evident that the detonation and decompofition muft be owing to the charcoal of the coal; and that therefore the quantity of coal neceffary to decompofe a given portion of nitre will indicate the quantity of carbon which it contains: and the proportion of charcoal and earth which any coal contains being afcertained, its bituminous part may be eafily had from calculation.

† *Macquer's Dictionary*, 2d edit. p. 481.

‡ *Mineralogy*, ii. 522.

The crucible which he ufed in his experiments was large: it was placed in a wind furnace at a diftance from the flue, and the heat in every experiment was as equal as poffible. The moment the nitre was red hot, the coal, previoufly reduced to fmall pieces of the fize of a pin head, was projected in portions of one or two grains at a time, till the nitre would no longer detonate; and every experiment was repeated feveral times to enfure accuracy.

He found that 480 grains of nitre required 50 grains of Kilkenny coal to decompofe it by this method. Therefore 10 grains would have decompofed 96 of nitre; precifely the quantity of charcoal which would have produced the fame effect. Therefore Kilkenny coal is compofed almoft entirely of charcoal.

Cannel coal, when incinerated, left a refiduum of 3.12 in the 100 parts of earthy afhes. 66.5 grains of it were required to decompofe 480 grains of nitre; but 50 parts of charcoal would have been fufficient: therefore 66.5 grains of cannel coal contain 50 grains of charcoal, and 2.08 of earth; the remaining 14.42 grains muft be bitumen. In this manner may the compofition of any other coal be afcertained.

320 Method of analyfing fulphur.

As for fulphur, in order to afcertain any accidental impurities with which it may be contaminated, it ought to be boiled in thirty times its weight of water, afterwards in diluted muriatic acid, and laftly in diluted nitro muriatic acid. Thefe fubftances will deprive it of all its impurities without acting on the fulphur itfelf, at leaft if the proper cautions be attended to. The fulphur may then be dried and weighed. The deficiency in weight will mark the quantity of the fubftances which contaminate the fulphur. The folutions may be evaporated and examined, according to the rules laid down in the fecond and fourth fections of this chapter.

Sect. IV. *Of the Analyfis of Ores.*

321 No general method of analyfing ores.

The method of analyfing ores muft vary confiderably, according to the metals which they are fufpected to contain. A general method, therefore, of analyfing would be of no ufe, even if it could be given, becaufe it would be too complicated ever to be practifed. We fhall content ourfelves with exhibiting a fufficient number of the analyfis of ores, to take in moft of the cafes which can occur. He who wifhes for more information on the fubject, may confult the treatife of Bergman on the *Analyfes of Ores*; Mr Kirwan's treatife on the fame fubject; and, above all, he ought to ftudy the numerous analyfes of ores which have been publifhed by Mr Klaproth.

I. Analyfis of Red Silver Ore.

322 Method of analyfing red filver ore.

Mr Vauquelin analyfed this ore as follows:

He reduced 100 parts of it to fine powder, poured over it 500 parts of nitric acid previoufly diluted with water, and applied a gentle heat to the mixture. The colour of the powder, which before the mixture with nitric acid was a deep purple, became gradually lighter, till at laft it was pure white. During this change no nitrous gas was extricated; hence he concluded, that the metals in the ore were in the ftate of oxides.

When the nitric acid, even though boiled gently, did not appear to be capable of diffolving any more of the powder, it was decanted off, and the refiduum, after being carefully wafhed, weighed 42.06.

Upon thefe 42.06 parts concentrated muriatic acid was poured; and by the application of heat, a confiderable portion was diffolved. The refiduum was repeatedly wafhed with muriatic acid, and then dried. Its weight was 14.6666. One portion of thefe 14.6666 parts, when thrown upon burning coals, burnt with a blue flame and fulphureous fmell. Another portion fublimed in a clofe veffel without leaving any refiduum. In fhort, they had all the properties of fulphur. Therefore 100 parts of red filver ore contain 14.6666 of fulphur.

The muriatic acid folution was now diluted with a great quantity of water; it became milky, and depofited a white flaky powder, which when wafhed and dried weighed 21.25. This powder, when heated with tartar in a crucible, was converted into a bluifh white brittle metal, of a foliated texture, and poffeffing all the other properties of antimony. Red filver ore, therefore contains 21.25 of oxide of antimony.

The folution in nitric acid remained now to be examined. When muriatic acid was poured into it, a copious white precipitate appeared, which, when wafhed and dried, weighed 72.66. It had all the properties of muriat of filver. According to Mr Kirwan's tables, 72.66 of muriat of filver contain 60.57 of oxide of filver. Therefore red filver ore, according to this analyfis, is compofed of

60.57	oxide of filver,
21.25	oxide of antimony,
14.66	fulphur.
96.48	

The

Analyſis of Minerals.

The loſs, which amounts to 3.52 parts, is to be aſcribed to unavoidable errors which attend ſuch experiments.

II. Antimoniated Silver Ore.

323 Analyſis of antimoniated ſilver ore.

Klaproth analyſed this ore as follows:

On 100 parts of the ore, reduced to a fine powder, he poured diluted nitric acid, raiſed the mixture to a boiling heat, and after pouring off the acid, added new quantities repeatedly, till it would diſſolve nothing more. The reſiduum was of a greyiſh yellow colour, and weighed, when dry, 26.

Theſe 26 parts he digeſted in a mixture of nitric and muriatic acid; part was diſſolved, and part ſtill remained in the form of a powder. This reſiduum, when waſhed and dried, weighed 13 parts. It had the properties of ſulphur; and when burnt, left a reſiduum of one part, which had the properties of ſilica. Antimoniated ſilver ore, therefore, contains, in the 100 parts, 12 parts of ſulphur and 1 of ſilica.

When the nitro-muriatic ſolution was diluted with about 20 times its weight of water, a white precipitate appeared; which, when heated to redneſs, became yellow. Its weight was 13. No part evaporated at a red heat: therefore it contained no arſenic. On burning coals, eſpecially when ſoda was added, part was reduced to a metal, having the properties of antimony; and in a pretty high heat, the whole evaporated in a grey ſmoke. Theſe 13 parts were therefore oxide of antimony: They contain about 10 parts of metallic antimony; and as the ſtate of oxide was produced by the action of the nitric acid, we may conclude that antimoniated ſilver ore contains 10 parts of antimony.

The nitric acid ſolution remained ſtill to be examined. It was of a green colour. When a ſolution of common ſalt was poured in, a white precipitate was obtained, which poſſeſſed the properties of muriat of ſilver. When dried, it weighed 87.75 parts; and when reduced, 65.81 parts of pure ſilver were obtained from it. Antimoniated ſilver ore, therefore, contains 65.81 of ſilver.

Into the nitric acid ſolution, thus deprived of the ſilver, he dropped a little of the ſolution of ſulphat of ſoda; but no precipitate appeared. Therefore it contained no lead.

He ſuperſaturated it with pure ammonia, on which a grey precipitate appeared. When dried, it weighed 5 parts. This, on burning coals, gave out an arſenical ſmell. It was rediſſolved in nitric acid; ſulphurated alkali occaſioned a ſmutty brown precipitate; and pruſſic alkali a pruſſian blue, which, after torrefaction, was magnetic. Hence he concluded, that theſe five parts were a combination of iron and arſenic acid.

The nitric ſolution, which had been ſuperſaturated with ammonia, was blue; he therefore ſuſpected that it contained copper. To diſcover this, he ſaturated it with ſulphuric acid, and put into it a poliſhed plate of iron. The quantity of copper was ſo ſmall, that none could be collected on the iron.

III. Grey Copper Ore.

324 Analyſis of grey copper ore.

Klaproth analyſed this ore as follows:

Three hundred grains of it, not completely freed from its matrix, were reduced to a fine powder; four times their weight of nitric acid was poured on them, and the whole was digeſted. The acid was then poured off, and an equal quantity again digeſted on the reſiduum. The two acid ſolutions were mixed together. The reſiduum was of a yellowiſh grey colour, and weighed 188 grains.

On this reſiduum ſix times its weight of muriatic acid was boiled. The reſiduum was waſhed, firſt with muriatic acid, and afterwards with alcohol, and the waſhings added to the muriatic acid ſolution. The reſiduum, when dried, weighed 105.5 grains. Part of it burned with a blue flame; and was therefore ſulphur. The reſiduum amounted to 80.25 grains, and had the properties of ſilica. When melted with black flux, about ¾ths of a grain of ſilver were obtained from it. Thus 300 parts of grey copper ore contain 25.25 gr. of ſulphur, and 79.5 of ſilica.

The muriatic acid ſolution, which was of a light yellow colour, was concentrated by diſtillation, a few cryſtalls of muriat of ſilver appeared in it, which contained about ¼th grain of ſilver. The ſolution, thus concentrated, was diluted with a great quantity of water; a white precipitate was depoſited, which, when dried, weighed 97.25 grains. It poſſeſſed the properties of oxide of antimony, and contained 75 grains of antimony. Therefore 300 grains of grey copper ore contain 70 of antimony.

The nitric acid ſolution was of a clear green colour. A ſolution of common ſalt occaſioned a white precipitate, which was muriat of ſilver, and from which 31.5 grains of ſilver were obtained.

A little ſulphat of potaſs, and afterwards ſulphuric acid, were added, to ſee whether the ſolution contained lead; but no precipitate appeared.

The ſolution was then ſuperſaturated with ammonia; a looſe fleaky browniſh red precipitate appeared, which, when heated to redneſs, became browniſh black, and weighed 9¼th grains. This precipitate was diſſolved in muriatic acid; half a grain of matter remained undiſſolved, which was ſilica. The muriatic acid ſolution, when pruſſic alkali was added, afforded a blue precipitate; and ſoda afterwards precipitated 1.5 grains of alumina. Therefore 300 grains of grey copper ore contain 7.25 grains of iron, and 1.5 of alumina.

Into the nitric ſolution ſuperſaturated with ammonia, and which was of an azure blue colour, a poliſhed plate of iron was put: By this method 69 grains of copper were obtained.

IV. Sulphuret of Tin.

325 Analyſis of ſulphuret of tin.

Klaproth analyſed this ore as follows*:

On 120 grains of the ore reduced to powder, ſix times their weight of nitro-muriatic acid, compoſed of 2 parts of muriatic, and 1 of nitric acid, were poured. There remained undiſſolved 43 grains, which had the appearance of ſulphur; but containing green ſpots, was ſuſpected not to be pure. After a gentle combuſtion, 13 grains remained; 8 of which were diſſolved in nitro-muriatic acid, and added to the firſt ſolution. The remaining 5 were ſeparated by the filtre, and heated along with wax. By this method about a grain of matter was obtained, which was attracted by the magnet; and which therefore was iron. The reſiduum weighed 3 grains, and was a mixture of alumina and ſilica. Thus 120 grains of ſulphuret of tin contain 30 grains of ſulphur, 1 of iron, and 3 of alumina and ſilica.

* Obſervations on the Foſſils of Cornwall, p. 48.

The

Analysis of Minerals.

The nitro muriatic solution was completely precipitated by potass. The precipitate was of a greyish green colour. It was washed and dried, and again dissolved in diluted muriatic acid. Into the solution a cylinder of pure tin was put, which weighed exactly 217 grains. The solution became gradually colourless, and a quantity of copper precipitated on the cylinder of tin, which weighed 44 grains. To see whether it was pure, a quantity of nitric acid was digested on it; the whole was dissolved, except one grain of tin. Therefore 120 grains of sulphuret of tin contains 43 grains of copper.

The cylinder of tin now weighed only 128 grains; so that 89 grains had been dissolved. Into the solution a cylinder of zinc was put; upon which a quantity of tin precipitated. When washed and dried, it weighed 130 grains. The tin he melted with tallow and powdered charcoal; and when cold, he washed off the charcoal. Among the tin globules were found some black flocculi of iron, which weighed one grain. Deducting this grain, and the 89 grains of the tin cylinder which had been dissolved, we see that the 120 grains of sulphuret of tin contained 40 grains of tin besides the grain which had been detected in the copper.

V. Plumbiferous Antimoniated Silver Ore.

326 Analysis of plumbiferous antimoniated silver ore.

Klaproth analysed this ore as follows:

He digested 400 grains of it, reduced to a fine powder, first in five times its weight of nitric acid, and then in twice its weight of the same acid. He then diluted this last portion of acid with eight times its weight of water, and continued the digestion. The undissolved residuum, when washed and dried, weighed 326 grains.

On this residuum he boiled muriatic acid repeatedly. The solution, on cooling, deposited acicular crystals. These he carefully separated, and put by. The undissolved residuum weighed 51 grains. It had the properties of sulphur. When burned, it left one grain of silica.

The muriatic acid solution was concentrated to half its former bulk by distillation: this made it deposite more acicular crystals. He continued the distillation as long as any crystals continued to appear. He then collected the whole of these crystals together. They had the properties of muriat of lead. When mixed with twice their weight of black flux, and heated in a crucible lined with charcoal, they yielded $160\frac{1}{8}$ grains of lead.

Sulphuret of ammonia was now added to the muriatic acid solution; an orange-coloured precipitate appeared, which shewed that the solution contained antimony. It was precipitated by a copious effusion of water, and by soda. The oxide of antimony being reduced to a mass with Spanish soap, mixed with black flux, and heated in a lined crucible, yielded 28.5 grains of antimony.

Into the nitric acid solution, obtained by the first part of the process, a solution of muriat of soda was dropped; a white precipitate was deposited, and over it acicular crystals. These crystals he dissolved, by pouring boiling water on the precipitate. The water was added to the nitric acid solution. The white precipitate was muriat of silver: when heated with twice its weight of soda, it yielded 81.5 grains of silver.

He now concentrated the nitric acid solution by evaporation; and then adding a solution of sulphat of soda, a white precipitate was obtained, which had the properties of sulphat of lead, and weighed 43 grains. It contained 32 grains of pure lead.

He now poured ammonia into the solution; a pale brown precipitate was obtained, which weighed 40 grains, and which appeared to consist of oxide of iron and alumina. He redissolved it in nitric acid, precipitated the iron by prussic alkali, and the alumina by soda. The alumina, after being heated to redness, weighed 28 grains; consequently the oxide of iron was 12 grains, which is equivalent to 9 grains of iron.

VI. Molybdat of Lead.

Mr Hatchett analysed this ore as follows*:

On 250 grains of the ore, reduced to a fine powder, he poured an ounce of strong sulphuric acid, and digested the mixture in a strong heat for an hour. When the solution was cool, and had settled, he decanted it off, and washed the undissolved powder with pure water, till it came away tasteless. This operation was repeated twice more; so that three ounces of sulphuric acid were used. All these solutions were mixed together, and filtered.

327 Analysis of molybdat of lead.

* Phil. Trans. lxxxvi. 320.

Four ounces of a solution of carbonat of soda were poured upon the powder which remained undissolved, and which consisted of sulphat of lead. The mixture was boiled for an hour, and then poured off. The powder was then washed, and diluted nitric acid poured on it: The whole was dissolved, except a little white powder, which, when washed, and dried on a filter by the heat of boiling water, weighed seven-tenths of a grain. It possessed the properties of silica.

The nitric acid solution was saturated with pure soda; a white precipitate was obtained, which, when washed, and dried for an hour in a heat rather below redness, weighed 146 grains. It possessed the properties of oxide of lead.

To see whether this oxide of lead contained any iron, it was dissolved in diluted nitric acid, and the lead precipitated by sulphuric acid. The solution was then saturated with ammonia: a brown powder precipitated, which, when dried, weighed one grain, and had the properties of oxide of iron.

The sulphuric acid solution was of a pale blue colour: It was diluted with 16 times its weight of pure water, and then saturated with ammonia. It became of a deep blue colour, and appeared turbid. In 24 hours a pale yellow precipitate subsided, which, when collected on a filter, and dried by a boiling water heat, weighed 4.2 grains. Its colour was yellowish brown. Muriatic acid dissolved it, and prussiat of potass precipitated it from its solution in the state of prussian blue. It was therefore oxide of iron.

The sulphuric acid solution, saturated with ammonia, was gradually evaporated to a dry salt. This salt was a mixture of molybdat of ammonia and sulphat of ammonia. A strong heat was applied, and the distillation continued till the whole of the sulphat of ammonia was driven off; and to be certain that this was the case, the fire was raised till the retort became red hot. The residuum in the retort was a black blistered mass; three ounces of nitric acid, diluted with water, were poured upon it, and distilled off. The operation was again repeated.

Analysis of Minerals.

peated. By this method the oxide of molybdenum was converted into a yellow powder, which was yellow acid of molybdenum. It weighed 95 grains.

VII. Grey Ore of Manganese.

Mr Vauquelin analysed this ore as follows *.

* *Jour. de Min.* N° xvii. p. 12.

318 Analysis of grey ore of manganese.

When 200 grains of it were exposed to a strong heat in a retort, there came over 10 grains of water, and 18 cubic inches of oxygen gas, mixed with a little carbonic acid gas. The mineral now weighed only 176 grains. Therefore the weight of the gas was 14 grains.

On 200 grains of the same mineral muriatic acid was poured, and heat applied. 75 cubic inches of oxy-muriatic acid gas came over, which, though mixed with some carbonic acid gas, enflamed metals when reduced to powder. When no more gas came over, the residuum was boiled. The whole was dissolved except a white powder. which weighed 12 grains, and which possessed the properties of silica.

Carbonat of potass was poured into the solution; a white precipitate was obtained, which became black by exposure to the air, and weighed 288 grains Strong nitric acid was boiled on it repeatedly to dryness. It became of a deep black colour, and, when well washed with water and dried, weighed 164 grains. This powder was black oxide of manganese.

To see whether it contained iron, nitric acid, with a little sugar, was poured upon it, and digested on it. The acid dissolved it completely. Therefore no oxide of iron was present.

Into the water with which the black oxide of manganese had been washed, carbonat of potass was poured; a white powder precipitated, which, when dried, weighed 149 grains, and which possessed the properties of carbonat of lime.

VIII. Wolfram.

329 Analysis of wolfram.

Messrs Vauquelin and Hecht analysed this mineral as follows:

On 200 parts of Wolfram in powder, three times its weight of muriatic acid were poured, and the mixture boiled for a quarter of an hour: a yellow powder appeared, and the solution was of a brown colour. The acid was allowed to cool, and then carefully decanted off, and the residuum washed. The residuum was then digested for some hours with ammonia, which dissolved a part of it. The residuum was washed, and new muriatic acid again poured over it; then the residuum was digested with ammonia, as before: and the operation was continued till the whole wolfram was dissolved.

All the ammoniacal solutions being joined together, were evaporated to dryness, and the salt which remained was calcined: a yellow powder was obtained; it weighed 134 grains, and was yellow acid of tungsten.

Into the muriatic acid solutions, which were all mixed together, a sufficient quantity of sulphuric acid was poured to decompose all the salts. The solution was then evaporated to dryness; and the salts which were obtained by this evaporation were redissolved in water. A white powder remained, which weighed three grains, and which possessed the properties of silica.

The excess of acid of the solution was saturated with carbonat of potass; the liquor became brown, but nothing precipitated. When boiled, a red powder precipitated, and the brown colour disappeared. The addition of more carbonat of potass caused a farther precipitation of a yellowish powder. This precipitate consisted of the oxides of iron and manganese combined. Nitric acid was distilled off it repeatedly; it was then boiled in acetous acid. The acetous solution was precipitated by potass. Nitric acid was again distilled off it, and it was again boiled in acetous acid. This process was repeated till nitric acid produced no further change. The different powders which could not be dissolved in the acetous acid were collected, mixed with a little oil, and heated red hot. The powder became black, and was attracted by the magnet. It was therefore oxide of iron. It weighed 36 grains.

The acetous solution contained the oxide of manganese: It was precipitated by an alkali, and, when dried, weighed 12.5 grains.

IX. Oxide of Titanium and Iron.

330 Analysis of oxide of titanium and iron.

Vauquelin analysed this ore as follows:

A hundred parts of the ore, reduced to a fine powder, and mixed with 400 parts of potass, were melted in a silver crucible for an hour and a half. When cool, the mixture was diluted with water; a powder remained of a brick red colour, which when washed and dried weighed 124 parts.

The watery solution had a fine green colour; when an excess of muriatic acid was added, it became red. By evaporation the liquor lost its colour. When evaporated to dryness, a salt remained, which was totally dissolved by water. From this solution carbonat of potass precipitated two parts, which had the properties of oxide of manganese.

The 124 parts of residuum were boiled in a solution of pure potass for an hour. The solution was saturated with an acid, filtered, and carbonat of potass added, which precipitated three parts. These had the properties of oxide of titanium.

The remainder of the 124 parts of residuum, which still was undissolved, was boiled with diluted muriatic acid. The liquor became yellow, and deposited 46 parts of a white powder, with a tint of red. This powder was soluble in sulphuric and muriatic acids: from these solutions, it was precipitated of a brick red colour by the infusion of nut-galls; of a green colour by sulphuret of ammonia and prussiat of potass; and of a white colour by carbonat of potass and pure ammonia. A rod of tin made these solutions red; a rod of zinc made them violet. These 46 parts therefore are oxide of titanium.

The muriatic solution, from which these 46 parts were deposited, formed, with prussiat of potass, a prussian blue; and ammonia precipitated from it 50 parts, which had the properties of yellow oxide of iron.

INDEX.

A.

ACINOSE iron ore, n° 225.
Actinolite, shorlaceous, 89.
——— lameller, 99.
——— glassy, 91.
Actinote, 52.
Adamantine spar, 26.
Ædelite, 65.
Ætites, 225.
Agaric mineral, 96.
Agate, Iceland, 55.
Aigue marine, 36.
Alumina, native, 27.
Amalgam, native, 197.
Amber, 178.
Amiantus, 85.
Amphibole, 53.
Amygdaloid, 137.
Analcime, 68.
Andreolite, 62.
Anthracite, 165.
Anthracolite, 165.
Antimoniated silver ore, 186. 188.
Antimony, native, 248.
——— grey ore of, 249.
Apatite, 98.
Aqua marina, 36. and 61.
Argillaceous iron ore, 225.
Argillite, 79.
Arseniat of lead, 241.
Arsenic, native, 257.
Arsenio-phosphat of lead, 242.
Asbestinite, 86.
Asbestoid, 88.
Asbestus, 85.
Asphalt, 171.
Auriferous native silver, 181.
Auripigmentum, 258.
Axinite, 71.
Azure de cuivre, 210.

B.

Balass ruby, 28.
Baroselenite, 104.
Barytes, carbonat of, 103.
——— sulphat of, 104.
Basanite, 93.
Basaltine, 52.
Beryl, 61.
Bitumen, 166.
——— elastic, 172.
Bismuth, native, 254.
——— ochre, 256.
Black chalk, 123.
Blackish octohedral iron stone, 220.
Blende, 245.
Blue calx of copper, 210.
Bole, 118.
Boracite, 100.
Breccia, 138.
Brick red copper ore, 208.
Brittleness, n° 12.
Brown iron ore, 223.

C.

Calamine, 246.
Calciform silver ore, 190.
Cannel coal, 171. 176.
Carbon, 162.
Carbonat of lead, 239.
Cat's eye, 33.
Celestine, 107.
Ceylanite, 29.
Chalk, 96.
Chalcedony, 42.
Chert, 41.
Chlorite, 77.
Chrysoberil, 63.
Chrysolite, 83. 98.
——— oriental, 63.
Chrysoprasium, 33.
Cinnabar, native, 198.
Clay, 114. 127.
—— porcelain, 115.
—— common, 116.
—— potters, 116.
Coal, 173.
—— cannel, 171.
—— Kilkenny, 164.
—— parrot, 171. 176.
—— spurious, 177.
Cobalt ore, black, 263.
——— brown, 264.
——— dull grey, 261.
——— red, 266.
——— white, 262.
——— yellow, 265.
Colour, 8.
Columnar iron ore, 225.
Copper, pyrites, 205.
—— malm, 208.
—— ochre, 208.
Corivindum, 26.
Cork, mountain, 85.
Cornelian, 42.
Corneous mercury, 200.
——— silver ore, 192.
Corundum, 26.
Culm, Wales, 164.
Cupriferous sulphurated silver ore, 189.
Cyanite, 63.
Cymophane, 74.

D.

Delphinite, 73.
Diamond, 163.
Ductility, 12.

E.

Eagle stone, 225.
Emerald, 61.
Emery, 218.

F.

Feel, 17.
Felsite, 57.
Felspar, n° 58.
——— argentine, 49.
Fer oligiste, 221.
— pyrocete, 222.
Flint, 32.
Florid red copper ore, 208.
Fluor, 99.
Fracture, 13.
Fragments 16.
Fuller's earth, 119.

G.

Galena, 233.
Gangue, page 244, note.
Garnet, n° 70.
——— white, 60.
Glacies mariæ, 50.
Gneiss, 140.
Gold, native, 182.
Granatine, 142.
Granatite, 47.
Granilite, 144.
Granite, 138.
Granitell, 143.
Granular iron ore, 225.
Graphite, 217.
Green earth, 123.
—— sand of Peru, 209.
Grey copper ore, 207.
Gypsum, 97.

H.

Hæmatites, 223. 224.
Hardness, 11.
Hepatic mercurial ore, 199.
Hornblende, 53.
——— basaltic, 52.
——— resplendent, 54.
Hornslate, 40.
Hornstone, 41.
——— shistose, 92.
Hyacinth, 93.
——— blanche cruciforme, 62.
Hyalite, 64.
Hydrosulphuret of antimony, 251.

I.

Jade, 84.
Jargon, 93.
Jasper, 43.
Jet, 174.
Iron ore, 214.

K.

Kiffekil, 81.
Kraggstone, 150.
Kupfer lazur, 210.
——— nickel, 267.

L.

Lapis nephriticus, 84.
—— lazuli, 69.
Lava, 152.
Lazulite, 69.
Lead ochre, 238.
Lepidolite, n° 59.
Leucite, 60.
Lilalite, 59.
Lime, borat of, 100.
—— carbonat of, 96.
—— fluat of, 99.
—— phosphat of, 98.
—— sulphat of, 97.
Limestone, 96.
Lithomarga, 117.
Loam, 128.
Lowland iron ore, 226.
Lustre, 10.
Lydian stone, 92.

M.

Magnetic iron stone, 220.
——— sand, 220.
Malachite, 211.
Maltha, 170.
Manganese, black or brown ore of, 273.
——— grey ore of, 272.
——— red ore of, 275.
——— white ore of, 274.
Marl, 124.
Meadow lowland ore, 226.
Menachanite, 284.
Menalites, 34.
Mercury, 195.
Mica, 50.
Micaceous iron ore, 221.
Micarell, 45.
Mineral caoutchouc, 172.
——— pitch, 170.
——— tar, 169.
Molybdena, 279.
Molybdat of lead, 243.
Morassy iron ore, 227.
Mould, 125.
Mountain blue, 210.
——— green, 211.
Mountains, different, p. 240, note.
Mullen, 149.
Muriat of antimony, 252.
Muscovy glass, 50.
Myrsen, 81.

N.

Naphtha, 167.
Nickel ochre, 268.

O.

Obsidian, 55.
Olive copper ore, 213.
Olivine, 83.
Opal, 33.
Orpiment, 258.
Oviform, 96.
Oxygenated carbonat of copper, 211.

P.

Pechblende, 280.
Peridot, 83.

Petrilite,

Petrilite, n° 56.
Petroleum, 168.
Petrofilex, 41.
Phofphat of lead, 240.
Phofphorite, 98.
Pierre a fufil, 32.
—— de croix, 47.
Pifiform, 225.
Pitchftone, 34.
Platinum, native, 193.
Plumbago, 217.
Plumbiferous antimoniated filver ore, 234.
Plumofe antimonial ore, 250.
Porphyry, 151.
—— fhiftofe, 40.
Potftone, 76.
Prehnite, 72.
Pudding-ftone, 136.
Pumice, 157.
Puzzolano, 156.
Pyrites, 216.
Pyromachus, 32.
Pyroxen, 87.

Q.

Quartz, 30.
—— elaftic, 31.

R.

Realgar, 259.
Red antimonial ore, 251.
—— chalk, 121.
—— copper glafs, 208.
—— iron ore, 224.
—— lead ore of Siberia, 289.
Red filver ore, n° 191.
Reddle, 121.
Rock cryftal, 30.
Rubellite, 39.
Ruby, 28.
—— balafs, 28.
—— Bohemian, 30.
—— occidental, 36.
—— octohedral, 28.
—— oriental, 25.
—— fpinell, 28.

S.

Sagenite, 283.
Sand, 127.
Sandftone, 131.
Sappare, 74.
Sapphyr, oriental, 25.
—— occidental, 36.
Scapiform iron ore, 225.
Seafroth, 81.
Selenite, 97.
Serpentine, 75.
Shiller fpar, 54.
Shiftus, argillaceous, 79.
Shorl, 46.
—— green, 73.
—— prifmatic hexagon, 52.
—— red, 39. 283.
Shorlite, 38.
Sienite, 142.
Silex, 32.
Siliceous fpar, 78.
Silver, native, 184.
Sinople, 30.
Slate, n° 79.
Smaragdite, 80.
Sommite, 37.
Sound, 18.
Sparry iron ore, 227.
Specular iron ore, 221.
—— laminated, 222.
Spinell, 28.
Staurolite, 62.
Staurolithe, 47.
Staurotide, 47.
Steatites, 82.
Stilbite, 67.
Streak, 9.
Strontites, carbonat of, 106.
—— fulphat of, 107.
Structure, 15.
Sulphat of lead, 244.
—— zinc, 247.
Sulphur, 161.
Surface, 6.
Swampy iron ore, 226.
Swineftone, 96.

T.

Talc, 51.
Talcite, 51.
Telefia, 25.
Texture 14.
Thallite, 73.
Thumerftone, 71.
Till, 129.
Tin pyrites, 231.
Tinftone, 232.
Titanite, n° 285.
Topaze, ancient, 83.
—— falfe, 30.
—— occidental, 36.
—— oriental, 25.
—— Saxon, 36.
Tourmaline, 48.
Tranfparency, 7.
Trap, 146.
Tripoli, 44.
Tufa, teftaceous, 96.
Tungsten, 277.

V.

Vefuvian, 60.
Vitreous filver ore, 187.
—— copper ore, 204.
Volcanic afhes, 158.
Uranitic ochre, 281.

W.

Wacken, 148,
White copper ore, 203.
—— lead fpar, 239.
Witherite, 102.
Wolfram, 276.
Woodtin, 232.

Y.

Yanolite, 71.
Yellow chalk, 122.
—— copper ore, 208.

Z.

Zeolite, 66.
Zellertite, 52.
Zircon, 93.

Mirabeau. MIRABEAU (Honnoré Gabriel, Compte de), well known both by his writings and the active part which he took in bringing about the French revolution, was born in 1749 of a noble family. Throughout life he difplayed a fpirit averfe from every reftraint, and was one of thofe unhappy geniufes in whom the moft brilliant talents ferve only as a fcourge to themfelves and all around them. It is told by his democratical panegyrifts, as a wonderful proof of family tyranny under the old government, that not lefs than 67 *lettres de cachet* had been obtained by Mirabeau the father againft this fon and others of his relatives. This ftory, if true, proves, with at leaft equal force, what many anecdotes confirm, that, for his fhare of them, the fon was not lefs indebted to his own ungovernable difpofition than to the feverity of his parent. He was indeed a monfter of wickednefs. Debauchery, gaming, impiety, and every kind of fenfuality, were not enough for him. He was deftitute of decency in his vices; and to fupply his expences, fcrupled not to perform tricks which would difgrace a thief-catcher. His father and mother difagreeing, commenced a procefs of feparation; when Mirabeau, juft liberated from prifon for a grofs mifdemeanor, was in want of money. He went to his father, fided with him againft his mother, on whom he poured a torrent of invectives; and, for 100 guineas, wrote his father's memorial for the court. He then went to his mother; and by a fimilar conduct got the fame fum from her; and both memorials were prefented. That the father of fuch a man fhould frequently get him fhut up in prifon, can excite no furprife; for confinement only could withhold him from the perpetration of crimes.

The talents of Mirabeau led him frequently to employ his pen; and his publications form the chief epochas of his life. His firft publication was, 1. *Effai fur le Defpotifme*, "An Effay on Defpotifm," in 8vo. Next, in one of his confinements, he wrote, 2. a work in two vols 8vo, *On Lettres de Cachet*. 3. *Confiderations fur l'Ordre de Cincinnatus*, 8vo. A remonftrance againft the order of Cincinnatus, propofed at one time to be eftablifhed in America. The public opinion in America favoured this remonftrance, and it proved effectual. 4. His next work was in favour of the Dutch, when Jofeph II. demanded the opening of the Sheldt, in behalf of the Brabançons. It is entitled, *Doutes fur la Liberté de l'Efcaut*, 8vo. 5. *Lettre à l'Empereur Jofeph II. fur fon Réglement concernant l'Emigration*; a pamphlet of forty pages, in 8vo. 6. *De la Caiffe d'Efcompte*; a volume in 8vo, written againft that eftablifhment. 7. *De la Banque d'Efpagne*, 8vo; a remonftrance againft eftablifhing a French bank in Spain. A controverfy

Mirabeau. controversy arising upon this subject, he wrote again upon it. 8. Two pamphlets on the monopoly of the water company in Paris.

Soon after the publication of these works, he was sent in a public character to the court of Berlin; where he conducted the king's affairs just as he had formerly done those of his father and mother, fully ready to sacrifice all parties, and to sell himself to the highest bidder. With such a disposition, he could not long avoid the notice of the Prussian illuminees; and Nicolai Biester, Gedicke, and Leuchsenring, soon became his constant companions. At Brunswick he met with Mauvillon, the worthy disciple of Philo Knigg, and at that time a professor in the Caroline college. This was the man who initiated the profligate Marquis in the last mysteries of illuminism.

Mirabeau was still at Berlin when Frederick II. died. That monarch, as is well known, was a naturalist, who, holding this life for his all, encouraged the propagation of infidelity in his dominions, from which resulted the very worst consequences to the peace of society. Of this truth his successor Frederick William was duly sensible; and determined to support the church establishment in the most peremptory manner, consistent with the principles of religious toleration. He published, therefore, soon after his accession, an edict on religion, which is a model worthy of imitation in every country; but it was attacked with the greatest virulence in numberless publications. It was called an unjustifiable tyranny over the consciences of men; the dogmas supported by it were termed absurd superstitions; the king's private character and his religious opinions were ridiculed and scandalously abused. The most daring of these attacks was a collection of anonymous letters on the constitution of the Prussian states, universally believed to be the composition of Mirabeau, who certainly wrote a French translation, with a preface and notes more impudent than the work itself. The monarch is declared to be a tyrant; the people of the Prussian dominions are addressed as a parcel of tame wretches, crouching under oppression; and the inhabitants of Silesia, represented as still in a worse condition, are repeatedly called upon to rouse themselves, and assert their rights.

About this time he published, 9. An *Essai sur le Secte des Illuminés;* one of the strangest and most impudent books that ever appeared. In it he describes a sect existing in Germany, called the *Illuminated;* and says, that they are the most absurd and gross fanatics imaginable, waging war with every appearance of reason, and maintaining the most *ridiculous superstitions.* He gives some account of these, and of their rituals and ceremonies, as if he had seen them all; yet no such society as he describes ever existed: and Mirabeau employed his powers of deception, merely to screen from observation the real *illuminati,* by holding out to the rulers of states this *ignis fatuus* of his own brain. For a while the essay certainly contributed to blind the eyes of the German princes; and Nicolai, with others of the junto, adopting the whim, called Mirabeau's fanatics *Obscuranten,* and joined with him in placing on the list of *Obscuranten* several persons whom they wished to make ridiculous.

Long before his initiation in the mysteries of illuminism, Mirabeau had been acquainted with all the revolutionary powers of the masonic lodges; nor did he, when initiated, undervalue those which flowed, or might flow, from Weishaupt's inventive genius. On his return to France, he began to introduce the new mysteries among some of his masonic brethren. His first associate was the Abbe Talleyrand de Perigord, who had already begun to act the part of Judas in the first order of the church. But to have only introduced the mysteries was not sufficient for the Marquis; he would have teachers come from Germany, who were better versed than he was in the illuminizing arts. Well acquainted with the reasons that had induced the chiefs of the order to defer the conversion of France, he found means to convince them, that the time was now come for the accomplishment of their views; and at his request a deputation was sent by Spartacus to illuminize that great kingdom. See ILLUMINATI, n° 40, 41, *Suppl.*

When the assembly of Notables was convened at Paris, Mirabeau foretold that it would soon be followed by a meeting of the States; and at that period he published a volume against the stockjobbing, then carried to a great height, intitled, 10. *Denonciation de l'agiotage au Roi, et a l'Assemblée de Notables,* 8vo. A *lettre de cachet* was issued against him in consequence of this publication; but he eluded pursuit, and published a pamphlet as a sequel to the book. His next work was against M. Necker, 11. *Lettre á M. de Cretelle, sur l'Administration de M. Necker,* a pamphlet in 8vo. 12. A volume in 8vo, against the Stadtholdership: *Aux Bataves, sur le Stadthouderat.* 13. *Observations sur la maison de force appellé Bicetre,* an 8vo pamphlet. 14. Another tract, intitled, *Conseils à un jeune Prince qui sent la nécessité de refaire son education.* 15. He now proceeded to a larger and more arduous work than any he had yet published, on the Prussian monarchy under Frederick the Great: *De la Monarchie Prussienne sous Frederic le Grand,* 4 vols, 4to, or eight in 8vo. In this work he undertakes to define precisely how a monarchy should be constituted. When the orders were issued for convening the States-general, Mirabeau returned into Provence; and at the same time published, 16. *Histoire Secrette de la Cour de Berlin,* two volumes of letters on the Secret History of the Court of Berlin. This work was condemned by the parliament of Paris, for the unreserved manner in which it delivered the characters of many foreign princes. As the elections proceeded, he offered himself a candidate in his own order at Aix; but he was so abhorred by the noblesse, that they not only rejected him, but even drove him from their presence. This affront settled his measures, and he determined on their ruin. He went to the commons, disclaimed his being a gentleman, set up a little shop in the market-place of Aix, where he sold trifles; and now fully resolved what line he should pursue, he courted the commons, by joining in all their excesses against the noblesse, and was at last returned a member of the assembly.

In consequence of this, he went to Paris; where the part he took was active, and such as tended, in general, to accelerate all the violences of the revolution. He now published, periodically, 17. his *Lettres à ses Commettans,* Letters to his Constituents, which form, when collected, 5 vols 8vo. It is supposed, that the fatal measure of the junction of the three orders into one national

PLATE XXXVI.

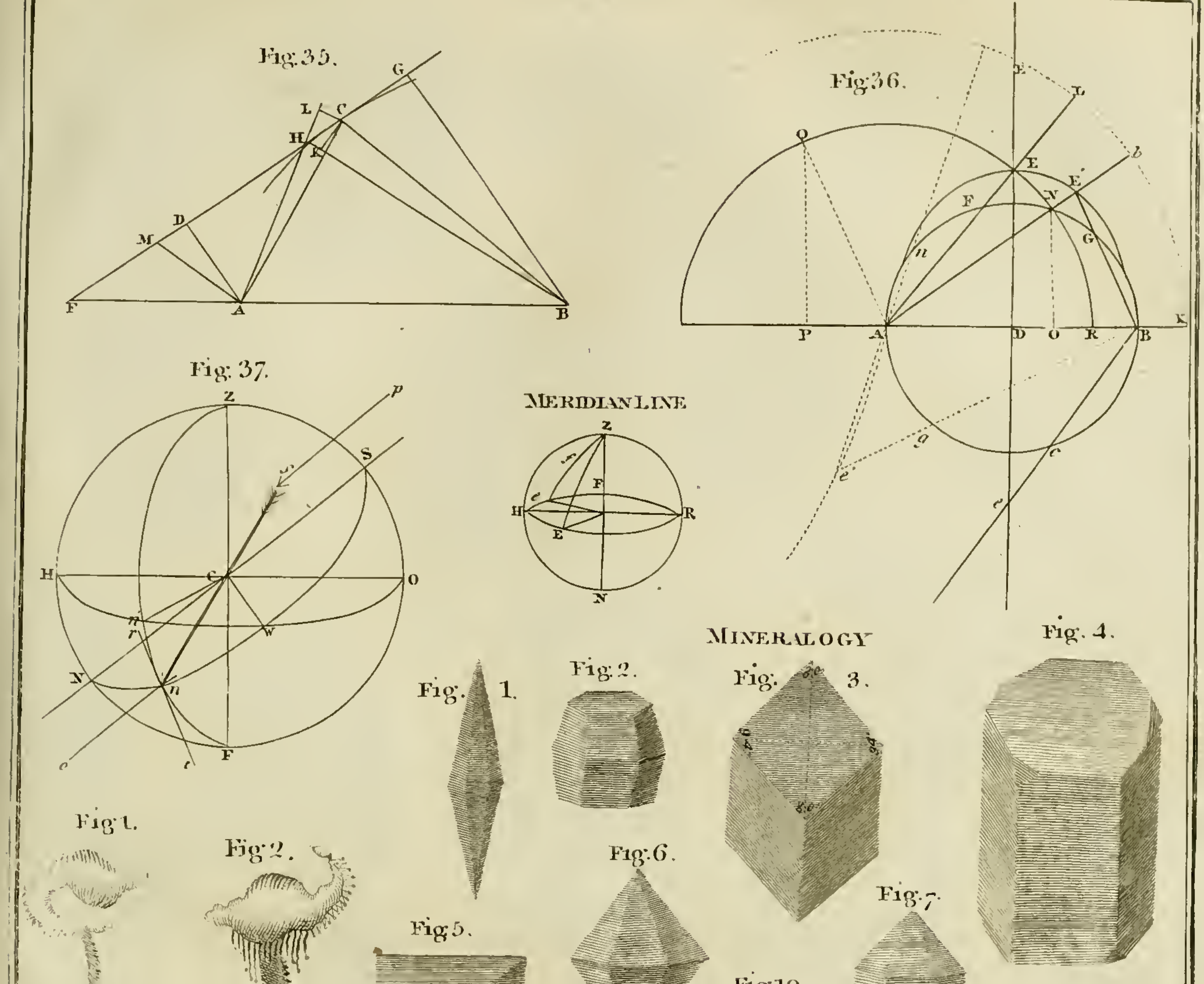
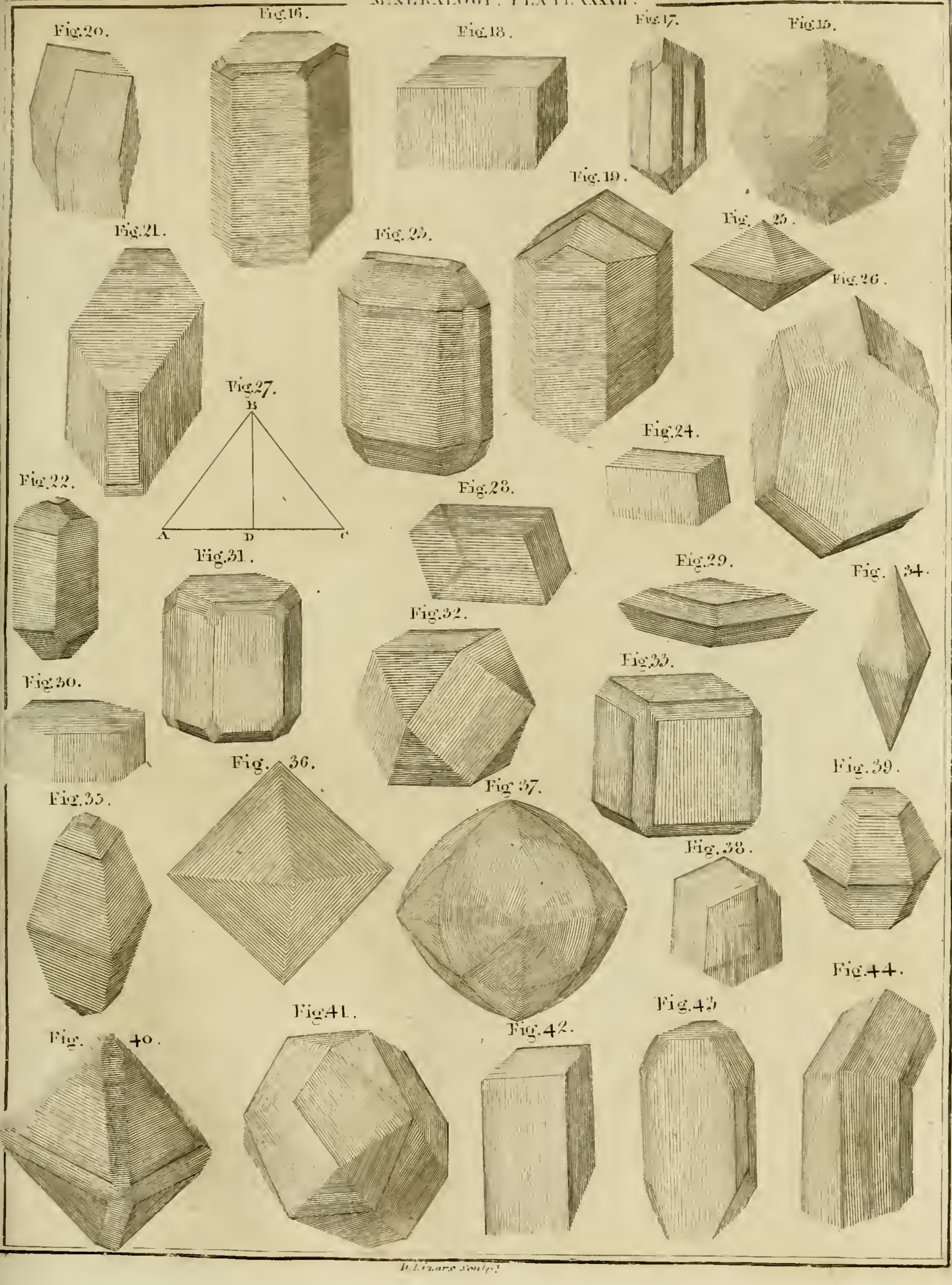


Fig.35.
Fig.36.
Fig. 37.
MERIDIAN LINE
MINERALOGY
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 1.
Fig. 2.
MEDUSA
R P R

MINERALOGY. PLATE XXXVII.



D. Lizars Sculpt

tional aſſembly, was greatly promoted by theſe letters. The public events of theſe times, and the part taken in them by Mirabeau, are the ſubject of general hiſtory. He lived to ſee the conſtitution of 1789 eſtabliſhed, but not to ſee its conſequences—the deſtruction of the monarchy, the death of the king, and the ruin of all property! He was accuſed, as well as the duke of Orleans, of hiring the mob which attacked Verſailles on the 5th and 6th of October 1789; but with him was alſo acquitted by the tribunal of the Châtelet. The dominion of his eloquence in the National Aſſembly had long been abſolute, and, on the 29th of January 1791, he was elected preſident. At the latter end of March, in the ſame year, he was ſeized by a fever, and died on the 2d of April.

The talents of Mirabeau will not be doubted, though they were certainly rather brilliant than profound. To be noticed, and to lead, were the ſole objects of his ambition; and for the attainment of them, he took the ſide of the diſcontented, as the beſt field for his matchleſs eloquence. Yet there was no man more devoted to the principles of a court than this Marquis, provided he could have a ſhare in the adminiſtration; and a ſhare he would have obtained, if any thing moderate would have ſatisfied him: But he thought nothing worthy of him but a place of active truſt, and a high department; ſtations which all knew him not qualified to fill. Wanting knowledge of great things, he was learned only in the buſtling detail of intrigue, and would, at any time, have ſacrificed his deareſt friend, and the intereſts of his country, for an opportunity of exerciſing his brilliant eloquence, and indulging his propenſity to ſatire and lampoon. But the greateſt obſtacle to his advancement under the old government was the abject worthleſſneſs of his character. Drinking was the only vice in which he did not indulge; and from this he was reſtrained by his exhauſted conſtitution. To his brother, the Viſcount, who was frequently intoxicated, the Marquis one day ſaid, "How can you, brother, ſo expoſe yourſelf? "What (replied the Viſcount)! how inſatiable are you? Nature has given you every vice; and having left me only this one, you grudge it me!

MISTRAL, the name of a wind, which is mentioned in almoſt every account that we have of Provence, and which is remarkable for blowing almoſt the whole year from north-weſt or weſt-north-weſt, in a climate where the wind ſhould be variable. It is ſaid to contribute to the ſalubrity of the air, by diſperſing the exhalations of the marſhes and ſtagnant waters, ſo common in the ſouth of Languedoc and Provence; but at times it is alſo very injurious, or at leaſt very troubleſome. It is not, however, on either of theſe accounts that it is introduced into this Work, but for the ſake of the cauſes aſſigned by Sauſſure for its conſtancy, which may be applied to other winds that nearly reſemble it; and which he found might be reduced to three.

"The firſt and moſt effectual cauſe (he ſays) is the ſituation of the Gulf of Lyons, the banks of which are the principal theatre of its ravages. This Gulf, in fact, is ſituated at the bottom of a funnel, formed by the Alps and Pyrenees. All the winds blowing from any point between weſt and north, are forced by theſe mountains to unite in the Gulf. Thus, winds which would not have prevailed but at one extremity of the Gulf, or even much beyond it, are obliged to take this route, after having undergone the repercuſſion of theſe mountains; and the middle of the Gulf, inſtead of the calm which it might have enjoyed, is expoſed to the united efforts of two ſtreams of wind, deſcending in different directions. Hence ariſe thoſe whirlwinds which ſeem to characteriſe the miſtral, and appear to have induced the ancients to call it *Circius*, *à turbine ejus ac vertigine*. See *Aul. Gellius*. l. ii. cap. 22.

"The ſecond cauſe is, the general ſlope of the grounds, deſcending from all ſides towards the Gulf; which becoming all at once lower and more ſoutherly than the lands extending behind it, is, from theſe joint circumſtances, rendered the hotteſt point of all the adjacent country: and, as the air on the ſurface of the earth always tends from the colder to the warmer regions, the Gulf of Lyons is actually the centre towards which the air from all colder points between eaſt and weſt muſt preſs. This cauſe, then, alone would be productive of winds directed to the Gulf, even if the repercuſſion of the mountains did not exert its influence.

"Finally, it is well known, that in all gulfs the land-winds blow more forcibly than oppoſite to plains and promontories, whatever be the ſituation of thoſe gulfs. I apprehend, indeed, on ſtrict examination (ſays our author), that this cauſe is blended with the preceding; but as the fact is generally admitted, and in ſome caſes can be explained only by reaſons drawn from the effects of heat, it may not improperly, perhaps, be diſtinctly mentioned. It is, at leaſt, neceſſary to ſuppoſe, that ſeveral cauſes produce the miſtral, in order to underſtand why, notwithſtanding the variableneſs of the ſeaſons and temperatures, that wind is ſo ſingularly conſtant in Lower Languedoc and Lower Provence. A very remarkable inſtance of this conſtancy is recorded by the Abbé Papon, in his *Voyage de Provence*, tom. ii. p. 81. He aſſerts, that during the years 1769 and 1770, the miſtral continued for fourteen months ſucceſſively. But the three cauſes which I have ſtated, taken ſeparately, will explain its frequency, and, united, will account for its force."

MIXT ANGLE, or *Figure*, is one contained by both right and curved lines.

Mixt Number, is one that is partly an integer and partly a fraction; as $3\frac{1}{7}$.

Mixt Ratio, or *Proportion*, is when the ſum of the antecedent and conſequent is compared with the difference of the antecedent and conſequent;

$$\text{as if}\left\{\begin{array}{l} 4:3::12:9 \\ a:b::c:d \end{array}\right.$$

$$\text{then}\left\{\begin{array}{l} 7\ :\ 1\ ::\ 21\ :\ 3 \\ a+b:a-b::c+d:c-d. \end{array}\right.$$

MOCASSIMAH, in Bengal, revenue ſettled by a diviſion of the produce.

MOCHULKAH, bond or obligation.

MŒRIS, a lake in EGYPT, occaſionally mentioned in that article (*Encycl.*), and generally ſuppoſed the production of human art. Of this, however, Mr Brown ſays it bears no mark. "The ſhape, as far as was diſtinguiſhable, ſeems not inaccurately laid down in D'Anville's map, unleſs it be, that the end neareſt the Nile ſhould run more in a north-weſt and ſouth-eaſt direction. The length may probably be between 30 and 40 miles; the breadth, at the wideſt part he could gain, was 5000 toiſes, as taken with a ſextant; that is, nearly ly six miles. The utmost possible extent of circuit must of course be 30 leagues. On the north-east and south is a rocky ridge, in every appearance primeval. In short, nothing can present an appearance more unlike the works of men. Several fishermen, in miserable boats, are constantly employed on the lake. The water is brackish, like most bodies of water under the same circumstances. It is, in the language of the country, *Birket-el-kerun*, probably from its extremities bearing some resemblance to horns.

MOFUSSEL, a relative term, signifying the subordinate lands or districts, opposed to SUDDER, which is the head.

MOHACZ, MOHATZ, or *Mohoz*, a town in the Lower Hungary, upon the Danube, between the river Sarwizu to the north, and the Drave to the south; four German miles from either, six from Esseck to the north, and nine from Colocoa to the south. This otherwise small place is memorable for two great battles here fought; the first between Lewis king of Hungary and Solyman the Magnificent, in 1526: in which that unfortunate Prince Lewis (being about 20 years old), with 25,000 men, fought 300,000 Turks; when, being overpowered by numbers, 22,000 of the Christian army were slain upon the place; 5000 waggons, eighty great cannon, 600 small ones, with all their tents and baggage, were taken by the victors; and the King, in his flight over the brook Curass, fell into a quagmire, and was swallowed up. After which, Solyman took and slew 200,000 Hungarians, and got such a footing in that kingdom, that he could never be expelled. This fatal battle was fought October 29. The second, in some part, retrieves the loss and infamy of the former. The Duke of Loraine being sent by the Emperor, with express orders to pass the Drave and take Esseck, his highness, July 10, 1687, with great difficulty passed that river, then extremely swelled with rains; but finding the Prime Visier encamped at Esseck, with an army of 100,000 men, so strongly, that it was not possible to attack him in that post without the ruin of the Christian army, he retreated, and repassed it the 23d of the same month; where, upon the 29th, the Prime Visier passed that river at Esseck; and upon August 12th, there followed a bloody fight, in which the Turks lost 100 pieces of cannon, 12 mortars, all their ammunition, provision, tents, baggage, and treasure, and about 8000 men upon the place of battle, besides what were drowned in passing the river, which could never be known. After which victory, General Dunewalt, September 30th, found Esseck totally deserted by the Turks, and took possession of it.

MOHER, in Bengal, a gold coin, worth about 33 shillings.

MOHERIR, a writer of accounts.

MOINEAU, a flat bastion raised before a curtin when it is too long, and the bastions of the angles too remote to be able to defend one another. Sometimes the moineau is joined to the curtin, and sometimes it is divided from it by a moat. Here musquetry are placed to fire each way.

MOLE (See TALPA, *Encycl.*), is an animal exceedingly troublesome, both to gardeners and farmers; and there are persons who contrive to make a livelihood by the trade of *mole-catching*. These men, it is well known, are generally quacks and cheats; and the secrets which they sell for extirpating those destructive animals are of very little avail. Even poison seldom produces any considerable effect; because the mole, while it does not drink, lives only on roots and worms. Under the word MOLE (*Encycl.*), some directions will be found for clearing fields of this destructive animal; but the following are perhaps preferable, as they seem to have been the result of much experience:

Immediately at day-break, it will be necessary to make a tour round the garden or meadow, from which it is wished to extirpate the moles; for at that time they will be all found at work, as may be seen by the hills newly thrown up. If the person is then close to the hill, he must proceed as the gardeners do, and turn up with a stroke of the spade the hill together with the digger. The passage is then cut through before the animal is aware of the attack; and therefore it has not power to escape. If the mole-hill be fresh, even though the animal may not be throwing up earth, the person ought not to lose his time in waiting, but should immediately proceed to the operation above-mentioned.

If you find a fresh hill standing by itself, which seems to shew by its situation that it has no communication with any other, which is always the case when the mole has worked from the surface downwards in endeavouring to procure a more convenient habitation, after the hill has been turned up with the spade, a bucket of water should be poured over the mouth of the passage. By these means the animal, which is at no great distanc, will be obliged to come forth, and may be easily caught with the hand.

You may discover also whether a hill has any communication with another, if you apply your ear to it, and then cough or make a loud noise. If it has no communication with the neighbouring hills, you will hear the terrified animal make a noise by its motion. It will then be impossible for it to escape; and you may either pour water into the hole, or turn up the hill with a spade, until the mole is found; for, in general, it never goes deeper into the earth than from fifteen to eighteen inches.

When any of the beds in a garden have been newly watered, the mole, attracted by the coolness and moisture, readily repairs thither, and takes up its residence in them, making a passage at the depth of scarcely an inch below the surface. In that case it may easily be caught. When you see it at work, you need only tread behind the animal with your feet on the passage to prevent its retreat, and then turn up the hill with a spade; by which means you will be sure to catch it.

When you dig after it with a spade, the animal forces its way downwards into the earth in a perpendicular direction, in order that it may the better escape the threatened danger. In that case it will not be necessary to dig long, but to pour water over the place, which will soon make the animal return upwards.

People, in general, are not aware of the great mischief occasioned in fields and gardens by these animals. We are, however, informed by Buffon, that in the year 1740 he planted fifteen or sixteen acres of land with acorns, and that the greater part of them were in a little time carried away by the moles to their subterranean retreats. In many of these there were found half a bushel, and in others a bushel. Buffon, after this circumstance, caused a great number of iron traps to be constructed;

Moments, Mongearts. constructed; by which, in less than three weeks, he caught 1300. To this instance of the devastation occasioned by these animals, we may add the following: In the year 1742 they were so numerous in some parts of Holland, that one farmer alone caught between five and six thousand of them. The destruction occasioned by these animals is, however, no new phenomenon. We are informed by history, that the inhabitants of the island of Tenedos, the Trojans, and the Æolians, were infested by them in the earliest ages. For this reason a temple was erected to Apollo Smynthius, the destroyer of moles. See *Economische Hefte*, Vol. VII. Part 5. and Vol. IX. Part 4.; or *Phil. Magazine*, N° 5.

MOMENTS, in the new doctrine of infinites, denote the indefinitely small parts of quantity; or they are the same with what are otherwise called infinitesimals and differences, or increments and decrements; being the momentary increments or decrements of quantity considered as in a continual flux.

Moments are the generative principles of magnitude; they have no determined magnitude of their own, but are only inceptive of magnitude.

Hence, as it is the same thing if, instead of these moments, the velocities of their increases and decreases be made use of, or the finite quantities that are proportional to such velocities; the method of proceeding which considers the motions, changes or fluxions of quantities, is denominated by Sir Isaac Newton, the *method of fluxions*.

Leibnitz, and most foreigners, considering these infinitely small parts, or infinitesimals, as the differences of two quantities, and thence endeavouring to find the differences of quantities, *i. e.* some moments, or quantities indefinitely small, which taken an infinite number of times shall equal given quantities, call these moments differences; and the method of procedure, the differential calculus.

MONGEARTS, one of the tribes of wandering Arabs which inhabit the SAHARA, or Great Desert of Africa. Their time is wholly occupied by tending their cattle; and because they are little skilled in the use of arms, *Mongeart* is a term of contempt among the people by whom they are surrounded. The country, with its produce, will be described under the title SAHARA in this *Supplement*; it is the business of this article merely to exhibit the manners of the people.

They are all Mahometans, and offer up prayers three times a-day, sometimes oftener; but having no mosques, these prayers are never pronounced in public, except when the horde is visited by a priest, who seldom comes but upon account of the childrens education. Then all the Arabs assemble at the hour of prayer, place themselves in a line, turn to the east, and, wanting water in the desert, rub their face and hands with sand; while the priest recites aloud the general prayer. It is the same as that which is rehearsed by the public crier in the mosques in civilized countries.

The priests are employed in travelling about the country to instruct the children. There is nothing like force in their education. The little boys meet in the morning of their own accord, at the place of instruction, which is to them a place of recreation. They go there with a small board inscribed with the Arabic characters, and a few maxims of the Koran. The oldest, and the best informed, receive their lessons directly from the priests, and afterwards communicate them to their fellows. They are never corrected; because it would be a crime to beat a child, who, according to the received notions, has not sufficient reason to distinguish good from evil. This lenity extends even to the children of Christians, though in a state of slavery. They are treated in all respects like the children of Arabs; and the man who should be rash enough to strike one of them would endanger his life. Very different is their treatment of Negro children; who may indeed join in all the amusements of the young Arabs, and even attend the public schools; but if they be guilty of a fault, they are severely punished.

Mongearts. When the child of a Mongeart becomes tired of the places of public instruction, he quits them at pleasure, and, without feeling constraint, or hearing reproach, goes and employs himself in tending his father's flocks: and accordingly there are very few among them who can read. Those who persevere in the study of the Koran are made priests, after having past an examination before the learned elders, and enjoy the greatest public consideration. They have no need of cattle; for those of the nation being theirs, they find their subsistence everywhere.

It is generally at seven or eight years of age that children undergo the painful operation of circumcision. Their head is also shaved, nothing being left but four locks of hair; one of which is cut off in a meeting of the family, at each remarkable action performed by the child. If, at the age of 12 or 13, he kill a wild boar, or other beast of prey, that should fall upon his flock, he loses one of his locks. If, in the passage of a river, a camel be carried away by the stream, and he save it by swimming to its assistance, another is cut off. If he kill a lion, a tyger, or a warrior of an hostile nation, in a surprise or an attack, he is considered as a man, and his head is entirely shaved.

Different from the other Arabs their neighbours, and indeed from the Mahometans in general, the Mongearts trouble no man on account of his religion. The only one which they do not tolerate is the Jewish; and were a Jew to enter their territory, and have the misfortune to be taken, he would certainly be burnt alive.

According to M. Saugnier, the women are much more respected among the Mongearts than among the neighbouring nations; but the evidences which he gives of that respect are very extraordinary.

When a Mongeart is desirous of undertaking the care of a family, he pitches upon the girl that pleases him the most, and asks her of her father without further formality; nor can the latter refuse her, unless the man who pretends to her hand have done something contrary to the laws of the nation. The girl is conducted by her parents to the tent of her future husband, where there is always an abundant repast prepared for the ceremony. Presents are made to the father; but if the son-in-law be poor, his wife's family assist him, and furnish him with the means of increasing his flocks; if, on the contrary, he be rich, and the father poor, he supports the whole family in his own tent. The employment of the wife, thus married, is to prepare the food; to spin the goats and camels hair, of which the tents are made; to milk the cattle; to pick up the necessary supply of wood for the night; and when the hour of repast is come, to wait upon her husband. She then eats

Mongearts. by herself what has been left by him and his male slaves. She is, indeed, in no great danger of having a rival brought into the family; for though polygamy be allowed by his religion, the poverty of the Mongeart generally prevents him from taking a plurality of wives. She is, however, liable to be divorced at will when she does not bear boys; but if she have the good fortune to have one or more male children, her husband's regard for her is inconceivable. She has no longer a divorce to fear, has an absolute authority in the tent, and passes her whole time in conversation, sleep, or dancing, as she thinks fit. The captive negresses do all her work, and are no longer assisted in their labour by the Arab's wife, who treats them, on the contrary, with the greatest harshness and arrogance.

When a woman is not agreeable to her husband, or when he is disagreeable to her, they have it in their power to part. The formality in this case consists in the wife's retiring to her parents. If the husband be attached to her, he goes thither in quest of her; but if she persist in refusing to return, she is free, and at liberty to marry another. If, however, she have had a child, especially a boy, she has not the same privilege; in that case, if her retreat should last more than eight days, it might be punished with death.

When a man beats his wife, it is a sure sign that he is sincerely attached to her, and that he does not mean to part with her; if he content himself with reproaches, the wife thinks herself despised, and infallibly retires to her parents. Hence it is, that in the most trifling disputes the women are cruelly beaten: they prefer it to the complaints that the husband might make to their parents; this proof being the most certain one of a man's fondness for his wife. When a girl marries, she makes up her mind to such treatment, deeming it much more supportable than the humiliations she would otherwise experience from her family, in consequence of her husband's complaints.

The conjugal fidelity of the Mongeart women is incorruptible. Differing in their opinions from many other Mahometans, they believe themselves immortal like the men; but they do not flatter themselves with the possibility of happiness in the other world, unless they shall have been faithful to their husbands in this. Women, who have been false to their husband's bed, will be doomed, they think, to eternal slavery to the more virtuous part of their sex, without ever partaking, in the smallest degree, of their bliss.

Mongeart women often visit one another; and on those occasions, the honour consists in letting the female who comes to see her friend or relation do all the work of the tent. The visitor assumes the management of every thing, dresses the victuals, churns the butter, and keeps herself continually employed; while her friend entertains her with an account of the different affairs of the family or nation. The heartiness of the welcome is measured by the extent of the work submitted to the guest, who generally prepares double the usual quantity of food; so that the Arab is obliged to invite his neighbours to partake of the repast. The slaves are always pleased with these entertainments, a larger portion then coming to their lot. It is the business of the visitor to do the honours: nor will she suffer any body about her to remain dissatisfied.

The laws of hospitality are observed among the Mongearts as among all the wandering Arabs. Indeed they are carried to such a length, that were a man to enter the tent of him whom he had wounded, or even killed, he would there meet with a sacred and inviolable asylum, although surrounded by those who must naturally desire his ruin. The tent of the chief is always that to which strangers, upon their arrival in the horde, are directed. But the chief could not entertain, at his own expence, all the strangers that happen to pass; and therefore every tent in the horde is obliged to furnish him with two pounds of ground barley *per* week, to enable him to maintain the ancient hospitality.

The chiefs of hordes are always the eldest of their families. The difference of wealth is not considered: the chief often having several individuals at his house richer than himself, who nevertheless obey him in every particular. He is, properly speaking, their king; examines their difference with the old men, and judges without appeal. As to himself, he cannot be tried but by the chiefs of several hordes assembled. It is his business to determine the spots where the tents are to be pitched, the moment of departure, and the place where the caravan is to stop. If the pasturage do not suffice for the herds of all the horde, it divides, and the chief assigns the ground for the different encampments. They are very often composed of no more than seven or eight tents, according to the quality of the ground they meet with. The tent of the chief is always the largest and most lofty, and is placed in the centre of the divisions. When it is determined upon to quit an encampment, which never happens till the pasture is exhausted, the chief sets off to choose another spot. In these removals the women alone do all the work. Early in the morning they fold up the tent, and load every thing upon the camels backs; they then move slowly on, that the cattle may have time to feed upon the way.

Great respect is paid by the Mongearts to all old men, who enjoy the same prerogatives as the priests, and such Arabs as have visited the tomb of Mahomet at Mecca. Together with the chief they are the judges of the horde, and take cognizance of all offences, the pain of death being the only punishment which they cannot decree. An assembly of several chiefs is the only tribunal which can inflict capital punishment; but as the accused has generally a number of friends, it seldom happens that he is capitally convicted.

A war between two Mongeart tribes seldom happens, and is never bloody; but the different families destroy one another fast enough in their intestine broils. They are all thieves; and indeed theft is a crime only in the day-time, being authorised by law during the night, in order to compel them to take care of their cattle. Could they find redress when robbed by night, they would be less vigilant; and their herds and flocks would be more exposed to the wild beasts that over-run their country; but being obliged to be on their guard even against their nearest neighbours, they are always ready to repel both the lion and the tiger. Theft, even in the day-time, is so far from being punished, unless detected at the instant of commission, that when any thing is stolen unperceived, it becomes the lawful property of the thief. In vain would the rightful owner recognize it in his neighbour's tent; he cannot reclaim it; it ceases to be his from the moment he has been negligent in its care. Hence arises this peoples inclination for rapine; they

Mongearts. they do not think they commit a crime, and only follow, in this regard, a custom allowed by their laws.

When an Arab is going to market, or on his return from thence, if he do not take the greatest care to keep his journey a secret, he is often attacked. Neighbouring Arabs are desirous of profiting by his industry; and as there are no persons in the country appointed to apprehend robbers, the hope of booty spurs them on to the attack. That they may have nothing to fear, they lie in wait, when the night is coming on, for him whom they mean to pillage. Their intention is never to kill; they only endeavour to surprise, to disarm, and to make themselves masters of every thing that comes in their way. But it sometimes happens, that the man they intend to plunder, being acquainted with the customs of his country, keeps an attentive ear, stands on his guard, fires upon his assailants at the first motion he observes, and then fights desperately with his dagger. The report of the musket almost always brings out the neighbouring Arabs, who, in virtue of the laws of hospitality, take the defence of the weaker side. They run up well armed; and then woe to the aggressors, if they do not save themselves by a speedy flight.

The flocks and herds of the Mongearts are composed of nothing but sheep, goats, and camels; all animals patient of thirst. Horses are very scarce in these cantons, none but the possessors of numerous herds being able to keep them; because, for want of water, it is necessary to have milk in sufficient abundance to give it them to drink. Great care is taken to preserve the camel's urine, both to mix with milk, and to wash the different vessels in which they put their food. Detestable as is this mixture of milk and urine, they are often reduced to the use of it; hunger and thirst give a relish to every thing.

The only workmen useful to this nation are blacksmiths or goldsmiths, as they may be called indifferently. The Mongearts not being sufficiently laborious to apply themselves to such occupations, these workmen come from Bilidulgerid, and disperse themselves all over the different parts of the desert. Wherever there are tents they are sure to find work. They are fed for nothing, and receive besides the hire for their labour. They make trinkets for the women, such as ear-rings and bracelets, &c. mend the broken vessels, by rivetting them, and clean the arms. They are generally paid in skins, goats and camels hair, or ostrich feathers, according to their agreement. Those who have silver pay them a tenth part of its weight for any thing wrought out of that metal. On their return they sell what they have earned; four or five excursions at most enabling them to live afterwards at their ease in their own country.

The Mongearts always carry a leathern bag, suspended from their neck, in which they put their tinder, their pipe, and their tobacco. Their daggers are elegant; the hilt is always black, and inlaid with ivory; the blade is crooked, and sharp on either side; the sheath is of brass on one side, and of silver on the other, and of very tolerable workmanship. They wear sabres when they can get them, and prefer those of Spanish make. Their muskets are always highly ornamented; the stock is very small, and inlaid on every side with ivory, and the barrel embossed with brass or silver, according to the opulence of the owner. There is a spring to the lock, covering the priming, to prevent the piece from going off, contrary to the intention of him who carries it. The poor, who do not possess muskets, wear daggers, made like the Flemish knives, with leathern sheaths. They arm themselves also with a thick stick, to the end of which they fix a kind of iron wedge. This weapon is exceedingly dangerous at close quarters. Others carry *zagays*, or slender javelins. In a word, the principal riches of an Arab, and his highest gratifications, are a handsome musket and a good dagger. He prefers them to neatness of apparel; for as to dress, it is indifferent to him whether he be clothed in Guinea blues, woollen stuffs, or goats skins. Their arms being their principal ornament, they take particular care to put the muskets in leathern bags, by way of keeping them in good order, and preserving them from the rust. Mongearts.

All the riches of the Mongearts consist in their herds; and accordingly they take the greatest care to preserve them. If a beast be sick, every thing is done to cure it; no care is spared; it is even treated with more attention than a man: but when it evidently appears that there is no hope of saving its life, they kill and eat it. If it be a camel, the neighbours are called in to partake of the repast; if a goat, the inhabitants of the tent suffice for its consumption. An animal that dies without shedding blood is unclean. Its throat must be cut; the person who kills it turning to the east, and pronouncing beforehand the first words of the general prayer. An animal killed by a wild boar is unclean; nor is it eaten although its blood has been shed, because the wild boar is itself an unclean beast. That species is so numerous in the desart, that they do more mischief than all the other wild beasts together. The Arabs kill as many as they can, but never taste their flesh.

Whatever losses an Arab may meet with, he is never heard to complain; he rises superior to poverty, supports hunger, thirst, and fatigue, with patience, and his courage is proof against every event. God will have it so, says he: he employs, however, every means in his power to avert misfortune; and often exposes himself to the greatest dangers to procure matters of no real utility.

When a father of a family dies, all the effects in his tent are seized upon by the eldest son present at his decease. Gold, silver, trinkets, every thing disappears; and the absent children have only an equal share in the division of the cattle and the slaves. The girls are entirely excluded from all participitation, and take up their residence with their elder brother. If the deceased leave children in helpless infancy, the mother takes them with her to her sister's, if she have a sister married; if not, to her own maternal roof. The dead man's possessions, however, are not lost; the chief of the horde takes care of them, and delivers them in equal portions to the heirs, as soon as they are old enough to manage their own property. If an Arab die without male children, his wife returns to her relations, and his brother inherits his effects.

The Mongearts have a rooted abhorrence of the Spaniards, and never fail to massacre every man of that nation who is so unfortunate as to be shipwrecked on their coasts, while they reserve the women for sale at Morocco. The reason of this hatred is, that the inhabitants of the Canaries make frequent descents on the Mongeart coasts, and carry off men, women, cattle, and every

Monnier. every thing that they meet with; and these people, being ignorant of the fate of their countrymen, retaliate by death on all Spaniards that fall into their hands, whilst they treat the British and French as well as they can.

MONNIER (Peter Charles Le), was born at Paris on the 20th of November 1715. The profession of his father, or the rank which he held in society, we have not learned, and we are equally ignorant of the mode in which he educated his son. All that we know is, that young Monnier, from his earliest years, devoted himself to the study of astronomy; and that, when only sixteen years of age, he made his first observation, viz. of the opposition of Saturn. At the age of twenty he was nominated a member of the Royal Academy of Sciences at Paris. In the year 1735 he accompanied Maupertuis in the celebrated expedition to Lapland, to measure a degree of latitude. In 1748 he went to Scotland with Lord Macclesfield, to observe the annular eclipse of the sun, which was most visible in that country; and he was the first astronomer who had the pleasure to measure the diameter of the moon on the disk of the sun.

Louis XV. it is well known, was extremely fond of astronomy, and greatly honoured its professors: he loved and esteemed Le Monnier. I have seen the king himself (says Lalande) come out of his cabinet, and look around for Le Monnier; and when his younger brother was presented to him on his appointment to the office of first physician, his Majesty was pleased to wish him the merit and reputation of his brother the astronomer. All the remarkable celestial phenomena were always observed by the king, in company with Le Monnier. Thus he observed with him, at his chateau of St Hubert, the two celebrated transits of Venus thro' the disk of the sun in the years 1761 and 1769; as appears from the Memoirs of the Royal Parisian Academy of Sciences. It well deserves to be here recorded in what manner the king behaved during these important observations, and how little he disturbed his astronomers (the celebrated La Condamine being likewise permitted to observe the transit in his presence) in this occupation; the proper time for which, if permitted to pass by, could not be recalled. Le Monnier relates in his Dissertation, that "his Majesty perceiving that we judged the last contacts to be of the greatest importance, a profound silence at that moment reigned around us." At the transit of Venus in 1769, the king allowed the Marquis de Chabert, an intelligent and expert naval officer, who was just returned from a literary voyage to the Levant, to assist at the observation. In a court like that of Louis XV. so scrupulously observant of etiquette, these will be allowed to have been most distinguished marks of honour, and of royal favour and condescension.

In the year 1750, La Monnier was ordered to draw a meridian at the royal Chateau of Bellevue, where the king frequently made observations. The monarch on this occasion rewarded him with a present of 15,000 livres; but Le Monnier applied this sum of money likewise in a manner that redounded to the honour of his munificent sovereign and of his country, by procuring new and accurate instruments, with which he afterwards made his best and most remarkable observations. In 1742, the king gave him in Paris *Rue de la Poste*, a beautiful free dwelling, where, till the breaking out of the revolution, he resided, and pursued his astronomical labours, and where his instruments in part yet remain. Some of them the present French government has, at the instance of Lalande, purchased for the National Observatory. In 1751, the king presented him with a block of marble, eight feet in height, six feet in breadth, and fifteen inches in thickness, to be used for fixing his mural quadrant of five feet. This marble wall, together with the instruments appended to it, turns on a large brass ball and socket, by which the quadrant may be directed from south to north; thus serving to rectify the large mural quadrant of eight feet, which is immoveably made fast to a wall towards the south.

With these quadrants Le Monnier observed, for the long period of forty years, the moon with unwearied perseverance at all hours of the night. It is requisite, to be a diligent astronomer, to be able to conceive to what numberless inconveniences the philosopher is exposed during an uninterrupted series of lunar observations. As the moon during a revolution may pass through the meridian at all hours of the day or night; the astronomer who, day after day, prosecutes such observations, must be prepared at all, even the most inconvenient, hours, and sacrifice to them his sleep and all his enjoyments. How secluded from all the pleasures of social intercourse, and how fatiguing such a mode of life is, those astronomers, indeed, know not who then only set their pendulum clocks in motion, when some of the eclipses of the sun, moon, or of the satellites of Jupiter, are to be viewed. At this time, and in the present state of the science, these are just the most insignificant observations; and an able astronomer, well supplied with accurate instruments, may *every* day, if he take into his view the whole of his profession, make more important and more necessary observations.

Le Monnier was Lalande's preceptor, and worthy of such a scholar; and he promoted his studies by his advice, and by every other means in his power. Le Monnier's penetrating mind, indeed, presaged in young Lalande, then only sixteen years old, what in the sequel has been so splendidly confirmed. In his twentieth year, he became, on the recommendation of his preceptor, a member of the Royal Academy: and in 1752 he was proposed by him as the fittest person to be sent to Berlin, to make with La Caille's, who had been sent to the Cape of Good Hope, correspondent observations, for the purpose of determining the parallaxes of the moon, then but imperfectly known. Le Monnier lent his pupil for this expedition his mural quadrant of five feet. His zeal for astronomy knew no bounds. For this reason Lalande, in his *Notice des Travaux du C. Le Monnier*, says of himself: "*Je suis moi-meme le principal resultat de son zele pour l'astronomie.*"

La Monnier was naturally of a very irritable temper: as ardently as he loved his friends, as easily could he be offended; and his hatred was then implacable. Lalande, as he himself expresses it, had the misfortune to incur the displeasure of his beloved preceptor; and he never after could regain his favour. But Lalande's gratitude and respect for him always continued undiminished, and were on every occasion with unremitting constancy publicly declared: patiently he endured from him undeserved ill treatment; so much did he love and esteem

eſteem his inſtructor and maſter to the day of his death. "I have not ceaſed to exclaim (writes Lalande, as Diogenes exclaimed to his maſter Antiſthenes, "You cannot find a ſtick ſtrong enough to drive me away from you!"

What a noble trait in the character of Lalande, who in 1797 wrote likewiſe an eulogium on Le Monnier in the ſtyle of a grateful pupil, penetrated with ſentiments of profound veneration and eſteem for his beloved maſter; but Le Monnier would not read it. This is not the place to give a circumſtantial account of this intricate quarrel: we ſhall only further remark, that Lalande was the warm friend and admirer of the no leſs eminent aſtronomer La Caille, whom Le Monnier mortally hated. An intimate friendſhip likewiſe ſubſiſted between Le Monnier and D'Alembert; but Lalande had no friendly intercourſe with the latter.

Among the ſcholars of Le Monnier may likewiſe be reckoned Henwart, the celebrated geometrician and profeſſor of mathematics at Utrecht; who, in a letter to Von Zach, aſtronomer to the Duke of Saxe Gotha, dated the 26th of May 1797, ſays, "Le Monnier is a penetrating and philoſophical aſtronomer: I learned much from him in Paris; though I lodged with the late De l'Iſle, where I frequently made obſervations in company with Meſſier. Le Monnier was the friend of D'Alembert; and conſequently an oppoſer of Lalande."

This great man, who had, for ſome years, ceaſed to exiſt either for the ſcience of aſtronomy, or for the comfort of his friends, died at Lizeaux, in the province of Normandy, in 1799, aged 84 years. He left behind him ſome valuable manuſcripts, and a number of good obſervations; with reſpect to which he had always been very whimſical, and of which in his latter years he never would publiſh any thing. He had by him a ſeries of lunar obſervations, and a multitude of obſervations of the ſtars, for a catalogue of the ſtars, which he had announced ſo early as the year 1741; among which was twice to be found the new planet Uranus: (See *Lalande's Aſtronomic, Tables*, p. 188, (A). The more he was requeſted to communicate his obſervations, the more obſtinate he became; he even threatened to deſtroy them. At the breaking out of the revolution, Lalande was greatly alarmed for the ſafety of theſe papers; he wiſhed to preſerve them from deſtruction, and made an attempt to get them into his poſſeſſion; but all his endeavours were in vain. He was only able to learn, that Le Monnier had hidden them under the roof of his houſe. Le Monnier having been firſt ſeized with a fit of the apoplexy ſo early as the 10th of November 1791, Lalande apprehended, leſt, if no one except himſelf ſhould know where he had hidden his papers, the infirm old man might perhaps have himſelf forgot it. He hopes, however, that La Grange, who married his ſecond daughter, may have ſome information concerning them. Le Monnier left behind him no ſon.

MONOMIAL, in algebra, is a ſimple or ſingle nomial, conſiſting of only one term; as a or ax, or $a^2 b x^3$, &c.

MONOTRIGLYPH, a term in architecture, denoting the ſpace of one triglyph between two pilaſtres, or two columns.

MONSELEMINES, are a people which inhabit that part of Biledulgerid (ſee *Encycl.*) that borders on the territories of the Emperor of Morocco. They are a mixed race, being deſcended from the ancient Arabs and fugitive Moors; and they occupy a ſpace of land, of which the limits are indicated by lofty columns placed at intervals towards the deſart. Their territory extends from about 30 leagues beyond Cape Non, to the diſtance of 20 leagues from St Croix or Agader. Though of different qualities, it is, for the moſt part, very fertile, and produces the neceſſaries of life with little cultivation. The plains are watered by an infinite number of ſtreams, and abound with palm, date, fig, and almond trees. The gardens produce excellent grapes, which are dried by the Arabs, and converted into brandy by the Jews. Great quantities of oil, wax, and tobacco, appear in the public markets.

More induſtrious and more laborious than their neighbours, the Monſelemine nation cultivates the earth. The chiefs of families chooſe the ground moſt fit for cultivation. Its ſurface is turned ſlightly over with a kind of hoe, and then the ſeed is ſown upon it: the field is ſurrounded with buſhes, to mark the ſpot, and to preſerve it from the cattle of the wandering Arabs. When the crop is ripe, which is generally at the end of Auguſt, three months after the ſowing of the ſeed, it is cut about ſix inches from the ear, and formed into little bundles; during which time every one labours without intermiſſion from morning to night. The corn is brought before the tent, thraſhed, winnowed, and placed in the magazines. When the harveſt is over, they ſet fire to the long ſtubble, and abandon the field for two or three years. Their magazines are large holes in the earth, formed like the fruſtum of a cone, the inſides of which are hardened by burning wood in them, before the half-winnowed corn be depoſited. When filled with corn, they are covered with planks placed cloſe to each other; over which a layer of earth is laid level with the ſoil, to prevent it from being diſcovered by enemies. In theſe magazines every one ſhares in proportion to the number of men he employed in the common labour.

The inhabitants of the plains remain by the cultivated fields in ſeed time, and return at the time of harveſt. During the intervals they wander in all directions with their cattle, taking only neceſſaries along with them, and having recourſe to the magazines when they require

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(A) Such is the French and German account of his diſcovery of this planet; but our readers have been very inattentive, if they have not perceived, in various articles of this Work, complete proofs of the plagiariſm of our neighbours on the Continent, from the celebrated philoſophers and divines of England. As it is extremely probable that, half a century hence, a claim may be put in for Le Monnier's diſcovery of the Georgium Sidus (*Uranus*), ſimilar to that which in 1757 the Editor of Abbè St Real's works put in for that Abbé being the author of Leſlie's *Short Method with the Deiſts* (ſee Leslie in this *Suppl.*), we think it our duty to declare, that in 1800 there was no evidence whatever on which to found that claim, and that the diſcovery was then univerſally allowed to have been made by Herſchel.

quire a fupply. The more opulent people, and the artizans who are engaged in fedentary occupations, dwell in towns, which are all fituated upon the declivity of hills. Their houfes are built of ftone and earth, according to the Moorifh conftruction, low and covered with floping terraces; yet they are fo much injured by the heavy rains which prevail for three months of the year, as to be rendered uninhabitable in 15 or 20 years. Thofe who refide in towns are generally weavers, fhoemakers, goldfmiths, potters, &c. and have no cattle; but the more opulent perfons have flocks and herds of cows, horfes, camels, fheep, goats, befides poultry, which are kept by their flaves at a diftance from the towns. In the towns they take two meals a-day; one at ten o'clock, and the other at the fetting of the fun, though the inhabitants of the country only eat in the evening. In the towns they fleep in mats upon the floors of their apartments, and make ufe of linen; but the inhabitants of the country fleep upon terraces in the open air. The paftoral families of the country practife hofpitality like thofe of the defart, and make the traveller pay nothing for his entertainment. In the towns this practice is impoffible, as the concourfe of ftrangers, efpecially on market-days, would foon impoverifh the inhabitants. In this manner hofpitality is always extinguifhed among a trading and commercial people. It is only where the fuperfluity of commodities runs neceffarily to wafte, that it is ever practifed iu a great extent; but where every commodity can find a market, every kind of property acquires a definite value, and will be preferved with the fame care as money.

By M. Saugnier the government of the Monfelemines is faid to be republican; but he writes inconfiftently about it. In one place, he fays that they choofe their chiefs annually; in another, that in the time of war they choofe from the natives or fugitive Moors indifcriminately, chiefs, whofe authority lafts no longer than the campaign, during which it is abfolute; and he afterwards reprefents their government as a kind of theocracy, during war as well as peace. But we muft follow him in his detail, as it has been well arranged in a late anonymous publication, entitled, *An Hiftorical Sketch of Difcoveries in Africa.*

At the end of each campaign, he fays the chief gives an account of his actions to the affembled aged men, and is rewarded or punifhed according to his conduct; after which his fucceffor is appointed, and he ferves in the army he commanded as an undiftinguifhed individual. The country is populous, and would be ftill more fo, were it not for the continual wars which its inhabitants are obliged to fupport againft the Emperor of Morroco. The liberty they enjoy imparts energy and courage to their character, and renders their arms invincible to the Moors. They confider it as the moft invaluable poffeffion, and defend it to the laft extremity. The nature of the country, furrounded on every fide by fteep and arid mountains, contributes to fruftrate the efforts of their enemies. The Monfelemine, richer than the fubject of Morocco, is always well clothed and armed. He pays no tribute, enjoys the fruit of his labour and commerce, and, as no contributions are requifite for the charges of the ftate, whatever he acquires is his own. The fugitive Moors are never armed, except when they go to battle; but the natives go continually armed, whether they refide in the country, refort to the markets, attend the affemblies of the nation, or pay vifits.

As the Monfelemine territory is the retreat of the rich Moors, who wifh to fly from the tyranny of the Emperor of Morocco, they are too well acquainted with the Moorifh cuftoms to be furprifed by that prince. No fooner does a Moorifh army take the field, than the inhabitants of the country cantons mount their horfes, and occupy the paffes of the mountains; while the women and flaves, efcorted by a fufficient number of warriors, retire to the anterior parts of the country, or, if they be hard preffed, to the defart. Among the paftoral tribes there are many that addict themfelves entirely to arms, and ferve as cavalry in the time of war. During peace they efcort caravans, or exercife themfelves in military evolutions, and the management of their horfes. Being almoft always on horfeback, and wearing no boots, they have a callous lump on that part of the leg that comes in contact with the iron of the ftirrup. Their horfes, which they break in an admirable manner, are the beft in the world: as they are treated with great care by their mafters, they know them, and are obedient to their voice, and will admit no ftranger to mount them.

The Monfelemines derive their origin and name from Mofeilama, a contemporary of Mahomet; and, in their love of liberty, as well as in many of their cuftoms, refemble the Arabs of remoter times. They refpect the prophet like other Mahometans; but neither believe that he was infallible, nor that his defcendants are all infpired by God, nor that their will fhould be a law, nor that fuch faith is neceffary in order to be a good Mahometan. Their priefts are refpected, and in old age generally become the civil judges of the nation; but the influence of the high prieft is almoft defpotic. Though he has no troops, he may command the nation; and war and peace depend upon his will. Though he has no property, every thing is at his difpofal: he requires nothing from any one, and yet all are inclined to give. He adminifters juftice according to the opinion of his counfel, without pretending to be infpired by the prophet.

On Friday the Monfelemines affemble in their mofques to pray: this is likewife the day of their principal market, when their merchandize is expofed to fale in the public fquares, where the old men judge without appeal, when difputes arife. Different from their neighbours of Morocco and Sahara, the Monfelemines never attempt to make profelytes. Their Chriftian flaves are treated with humanity; but they owe this to the avarice of their mafters. Thefe deteft Chriftians, but they love money, and are afraid left ficknefs or death fhould deprive them of the ranfom of the flave, or of the advantage of his labour. Among the inhabitants of the defart, a Chriftian, that adopts the religion of Mahomet, is admitted as a citizen and member of the family, and is prefented with cattle to form an eftablifhment. The Monfelemines pay more attention to the value of their property than the fituation of the infidel. A Chriftian who enters a mofque at Morocco is put to death, or forced to affume the turban. The Monfelemines would turn him civilly out, and content themfelves with impofing the higheft poffible fine. Among the Moors, a Chriftian difcovered in an intrigue with a woman of that nation fuffers death, or fubmits to

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Monfelemines, Monterey. conversion ; but the Monselemines prefer money to religion. From them the Christian has nothing to fear : the woman alone is punished, being put into a fack and thrown into the sea. If a Christian slave among the neighbouring nations defends himself against his master, he is punished with death ; but money saves him among the Monselemines ; he would at most receive a slight correction.

The Jews are allowed the free exercise of their religion among the Monselemines, but are treated with the same indignity as among other Mahometan tribes. A Jew is not permitted to carry arms ; and if he should make use of them against an Arab, he would be punished with death, and probably involve his family in his fate. The Jews inhabits the towns only, where they follow trade and various arts, but are not allowed to cultivate the earth.

Polygamy is permitted, as in other Mahometan countries ; but the situation of the women is more respectable, and they are not so much secluded as among the Moors. They mingle more in society, walk at large, and visit their friends ; neither are their apartments so inviolable. Among the Monselemines, that degrading picture of humanity is never seen which sometimes occurs in Morocco, a woman drawing the plough with an ass, a mule, or some other beast of burden. More happier than the women of the Sahara, and treated with greater attention by their husbands, they are more humane in their dispositions. Like other Arab women, they stain the edges of their eyelids black with henna, and paint their faces red and yellow. Their children are brought up with great care, and are not obliged to exhibit proofs of their courage before they can be considered as men, as is the custom in the desart. Avarice is the principal defect in the character of the Monselemines. They hoard their money with the utmost care, bury it in the earth, and in many cases die without discovering their secret even to their children. Misers, says M. Saugnier, should go to that country, where they would learn means of economy ; which would shew them, that, in comparison with the Monselemines, they are themselves perfect prodigals.

The medicinal applications of the Monselemines, which differ not from those of the MONGEARTS and other inhabitants of the desart, are extremely simple, but appear sufficiently complex from the mummery of the priests, who are the depositories of their medical science. Flesh wounds are cauterised with a hot iron, and then covered with herbs dipped in turtles oil and tar. In headachs, a compress is applied with such violence that the blood starts from the forehead. In internal diseases, the general remedies are regimen, rest, and a few maxims of the Koran mysteriously applied to the affected parts.

MONTEREY BAY, in North California, was visited in 1786 by La Perouse, who places it in 36° 58′ 43″ N. Lat. and 124° 40′ W. Long. from Paris. It is formed by New-year point to the north, and by that of Cyprus to the south ; has an opening of eight leagues in this direction, and nearly six of depth to the eastward where the land is sandy and low. The sea breaks there as far as the foot of the sandy downs with which the coast is surrounded, with a roaring which may be heard more than a league off. The lands north and south of this bay are high, and covered with trees. Those ships which are desirous of touching there ought to follow the south coast, and after having doubled the Point of Pines, which stretches to the northward, get sight of the presidency, and may come to an anchor in ten fathoms within it, and a little within the land of this point, which shelters from the winds from the offing. The Spanish ships, which propose to make a long stay at Monterey, are accustomed to bring up within one or two cables lengths of the land, in six fathoms, and make fast to an anchor, which they bury in the sand of the beach ; they have then nothing to fear from the southerly winds, which are sometimes very strong ; but, as they blow from the coast, do not expose them to any danger. The two French frigates, which our author commanded, found bottom over the whole bay, and anchored four leagues from the land, in 60 fathoms, soft muddy ground ; but there is a very heavy sea, and it is only an anchorage fit for a few hours, in waiting for day, or the clearing up of the fog. At full and change of the moon it is high water at half past one o'clock : the tide rises seven feet ; and as this bay is very open, the current in it is nearly imperceptible. It abounds with whales ; a genus of fishes, of which our *scientific* voyagers knew so little, that they were surprised at their spouting water !

The coasts of Monterey Bey are almost continually enveloped in fogs, which cause great difficulty in the approach to them. But, for this circumstance, there would be few more easy to land upon ; there is not any rock concealed under water that extends a cable's length from the shore ; and if the fog be too thick, there is the resource of coming to an anchor, and there waiting for a clear, which will enable you to get a good sight of the Spanish settlement, situated in the angle formed by the south and east coast. The sea was covered with pelicans. These birds, it seems, never go farther than five or six leagues from the land ; and navigators, who shall hereafter meet with them during a fog, may rest assured that they are within that distance of it.

A lieutenant-colonel, whose residence is at Monterey, is governor of the Californias : the extent of his government is more than 800 leagues in circumference, but his real subjects consist only of 282 cavalry, whose duty it is to garrison five small forts, and to furnish detachments of four or five men to each of the 25 missions, or parishes, established in old and new California. So small are the means which are adequate to the restraining about 50,000 wandering Indians in this vast part of America, among whom, nearly 10,000 have embraced Christianity. These Indians are, in general, small and weak (A), and discover none of that love of liberty and independence which characterises the northern nations, of whose arts and industry they are also destitute. Their colour very nearly approaches that of the negroes whose hair is not woolly ; the hair of these people is strong, and of great length ; they cut it four or five inches from the roots. Several among them have a beard ; others, according to the missionary fathers, have never had any ; and this is a question which is even undecided.

(A) The chief surgeon of the expedition says they are *strong*, but stupid.

Monterey. decided in the country. The governor, who had travelled a great way into the interior of these lands, and who had passed 15 years of his life among the savages, assured our author, that those who had no beards had plucked them up with bivalve shells, that served them as pincers: the president of the missions, who had resided an equal length of time in California, maintained the contrary;—it was difficult, therefore, for travellers to decide between them." The difficulty, surely, was not great. By their own account, the governor had travelled much farther into the country than the missionary; and his report being confirmed by the evidence of their own senses, was intitled to unlimited credit.

These Indians are extremely skilful in drawing the bow; they killed, in the presence of the French, the smallest birds: it is true, they display an inexpressible patience in approaching them; they conceal themselves, and, as it were, glide along near to the game, seldom shooting till within 15 paces. Their industry in hunting the larger animals is still more admirable. Perouse saw an Indian, with a stag's head fixed upon his own, walk on all fours, as if he were brousing the grass; and he played this pantomime to such perfection, that all the French hunters would have fired at him at 30 paces, had they not been prevented. In this manner they approach herds of stags within a very small distance, and kill them with a flight of arrows.

Before the Spanish settlements, the Indians of California cultivated nothing but maize, and almost entirely lived by fishing and hunting. There is not any country in the world which more abounds in fish and game of every description; hares, rabbits, and stags are very common there; seals and otters are also found there in prodigious numbers; but to the northward, and during the winter, they kill a very great number of bears, foxes, wolves, and wild cats. The thickets and plains abound with small grey tufted partridges, which, like those in Europe, live in society, but in large companies of three or four hundred; they are fat, and extremely well flavoured. The trees serve as habitations to the most delightful birds; and the ornithologists of the voyage stuffed a great variety of sparrows, titmice, speckled wood-peckers, and tropic birds. Among the birds of prey are found the white-headed eagle, the great and small falcon, the goss-hawk, the sparrow-hawk, the black vulture, the large owl, and the raven. On the ponds and sea-shore are seen the wild duck, the grey and white pelican with yellow tufts, different species of gulls, cormorants, curlews, ring-plovers, small sea water hens, and herons; together with the bee-eater, which, according to most ornithologists, is peculiar to the old continent.

The country about Monterey Bay is inexpressibly fertile. The crops of maize, barley, corn, and pease, cannot be equalled but by those of Chili; our European cultivators can have no conception of a similar fertility; the medium produce of corn is from seventy to eighty for one; the extremes sixty and a hundred. Fruit trees are still very rare there, but the climate is extremely suitable to them: it differs a little from that of the southern French provinces. The forest trees are, the stone-pine, cyprus, evergreen oak, and occidental plane-tree. There is no underwood; and a verdant carpet, over which it is very agreeable to walk, covers the ground. There are also vast savannahs, abounding with all sorts of game. Monterey

Perouse writes with great respect of the wise and pious conduct of the Spanish missionaries at Monterey, who so faithfully fulfil the purpose of their institution. Totally unlike the monks at Conception in Chili (see that article in this *Suppl.*), they have left the lazy life of a cloister, to give themselves up to cares, fatigues, and solicitudes of every kind. They invited the officers of the frigates to dine with them at their monastery, contiguous to which stands the Indian village, consisting of about 50 cabins, which serve as dwelling-places to 740 persons of both sexes, comprising their children, which compose the mission of Saint Charles, or of Monterey. These cabins are the most miserable that are to be met with among any people; they are round, six feet in diameter, by four in height; some stakes, of the size of an arm, fixed in the earth, and which approach each other in an arch at the top, compose the timber work of it; eight or ten bundles of straw, very ill arranged over these stakes, defend the inhabitants, well or ill, from the rain and wind; and more than half of this cabin remains open when the weather is fine; their only precaution is to have each of them two or three bundles of straw at hand by way of reserve.

All the exhortations of the missionaries have never been able to procure a change of this general architecture of the two Californias. The Indians say, that they like plenty of air; that it is convenient to set fire to their houses when they are devoured in them by two great a quantity of fleas; and that they can build another in less than two hours. The independent Indians, who as hunters so frequently change their places of abode, have a stronger motive.

The monks gave the most complete information respecting the government of this species of religious community; for no other name can be given to the legislation they have established. They are superiors both in spiritual and temporal affairs: the products of the land are entirely entrusted to their administration. There are seven hours allotted to labour in the day, two hours to prayers, and four or five on Sundays and festivals, which are altogether dedicated to rest and divine worship. Corporal punishments are inflicted on the Indians of both sexes who neglect pious exercises; and several sins, the punishment of which in Europe is reserved only to Divine Justice, are punished with chains or the stocks.

The Indians, as well as the missionaries, rise with the sun, and go to prayers and mass, which last an hour; and during this time there is cooked in the middle of the square, in three large kettles, barley meal, the grain of which has been roasted previous to being ground; this species of boiled food, which the Indians call *atole*, and of which they are very fond, is seasoned neither with salt nor butter, and to us would prove a very insipid mess. Every cabin sends to take the portion for all its inhabitants in a vessel made of bark: there is not the least confusion or disorder; and when the coppers are empty, they distribute that which sticks to the bottom to the children who have best retained their lessons of catechism. This meal continues three quarters of an hour, after which they all return to their labours; some go to plough the earth with oxen, others to dig the garden; in a word, every one is employed in different

Monterey. rent domeftic occupations, and always under the fuperintendance of one or two of the religious.

The women are charged with little elfe but the care of their houfewifery, their children, and roafting and grinding the feveral grains: this laft operation is very long and laborious, becaufe they have no other means of doing it but by crufhing the grain in pieces with a cylinder upon a ftone. M. de Langle, being a witnefs of this operation, made the miffionaries a prefent of his mill; and a greater fervice could not have been rendered them, as by thefe means four women would in a day perform the work of a hundred, and time enough will remain to fpin the wool of their fheep, and to manufacture coarfe ftuffs.

At noon the dinner was announced by the bell; the Indians quitted their work, and fent to fetch their rations in the fame veffels as at breakfaft: but this fecond mefs was thicker than the firft; there was mixed in it corn and maize, and peafe and beans; the Indians name it *pouffole*. They return again to their labour from two o'clock till four or five; afterwards they attend evening prayers, which continue near an hour, and are followed by a new ration of *atole* like that at breakfaft. Thefe three diftributions are fufficient for the fubfiftence of the far greater number of Indians; and this very economical foup might perhaps be very profitably adopted in our years of fcarcity; fome feafoning would certainly be neceffary to be added to it, their whole knowledge of cookery confifting in being able to roaft the grain before it is reduced into meal. As the Indian women have no veffels of earth or metal for this operation, they perform it in large bafkets made of bark, over a little lighted charcoal: they turn thefe veffels with fo much rapidity and addrefs, that they effect the fwelling and burfting of the grain without burning the bafket, though it is made of very combuftible materials.

The corn is diftributed to them every morning; and the fmalleft difhonefty, when they give it out, is punifhed by whipping: but it is very feldom, indeed, they are expofed to it. Thefe punifhments are adjudged by Indian magiftrates, called *caciques;* there are in every miffion three of them, chofen by the people from amongft thofe whom the miffionaries have not excluded: but thefe caciques are like the governors of a plantation, paffive beings, blind executors of the will of their fuperiors; and their principal functions confift in ferving as beadles in the church, and their maintaining order and an air of contemplation. The women are never whipped in public, but in an enclofed and fomewhat diftant place, left perhaps their cries might infpire too lively a compaffion, which might ftimulate the men to revolt; thefe laft, on the contrary, are expofed to the view of all their fellow-citizens, that their punifhment may ferve as an example. In general they afk pardon; in which cafe the executioner leffens the force of his lafhes, but the number of them is never receded from.

The rewards are particular fmall diftributions of grain, of which they make little thin cakes, baked on burning coals: and on the great feftivals the ration is in beef; many of them eat it raw, efpecially the fat, which they efteem equal to the beft butter or cheefe. They fkin all animals with the greateft addrefs; and when they are fat, they make, like the ravens, a croaking of pleafure, devouring, at the fame time, the moft delicate parts with their eyes.

They are frequently permitted to hunt and fifh on their own account; and on their return they generally make the miffionaries fome prefent in game and fifh; but they always proportion the quantity to what is abfolutely neceffary for them, always taking care to increafe it if they hear of any new guefts who are on a vifit to their fuperiors. The women rear fowls about their cabins, the eggs of which they give their children. Thefe fowls are the property of the Indians, as well as their clothes, and other little articles of houfehold furniture, and thofe neceffary for the chace. There is no inftance of their having robbed each other, though their faftenings to the doors confift only of a fimple bundle of ftraw, which they place acrofs the entrance when all the inhabitants are abfent.

The men in the miffions have facrificed much more to Chriftianity than the women; becaufe they were accuftomed to polygamy, and were even in the cuftom of efpoufing all the fifters of a family. The women, on the other hand, have acquired the advantage of exclufively receiving the careffes of one man only. With this, however, it would appear that they are not fatisfied; for the religious have found it neceffary to conftitute themfelves the guardians of female virtue. At an hour after fupper, they have the care of fhutting up, under lock and key, all thofe whofe hufbands are abfent, as well as the young girls above nine years of age; and during the day they are entrufted to the fuperintendance of the matrons. So many precautions are ftill infufficient; for our voyagers faw men in the ftocks, and women in irons, for having deceived the vigilance of thefe female arguffes, who had not been fufficiently fharp-fighted.

The converted Indians have preferved all the ancient ufages which their new religion does not prohibit; the fame cabins, the fame games, the fame dreffes: that of the richeft confifts of an otter's fkin cloak, which covers their loins, and defcends below their groin; the moft lazy have only a fimple piece of linen cloth, with which they are furnifhed by the miffion, for the purpofe of hiding their nakednefs; and a fmall cloak of rabbit's fkin covers their fhoulders, which is faftened with a pack-thread under the chin; the head and the reft of the body is abfolutely naked; fome of them, however, have hats of ftraw, very neatly matted. The womens drefs is a cloak of deer fkin, ill tanned; thofe of the miffions have a cuftom of making a fmall boddice with fleeves, of them: it is their only apparel, with a fmall apron of rufhes, and a petticoat of ftag's fkin, which covers their loins, and defcends to the middle of the leg. The young girls, under nine years of age, have merely a fimple girdle; and the children of the other fex are quite naked.

The independent favages are very frequently at war; but the fear of the Spaniards makes them refpect their miffions; and this, perhaps, is not one of the leaft caufes of the augmentation of the Chriftian villages. Their arms are the bow, and arrow pointed with a flint very fkilfully worked: thefe bows are made of wood, and ftrung with the finews of an ox. Our author was affured, that they neither eat their prifoners, nor their enemies killed in battle; that, neverthelefs, when they had

had vanquifhed, and put to death on the field of battle, chiefs, or very courageous men, they have eaten fome pieces of them, lefs as a fign of hatred or revenge, than as a homage which they paid to their valour, and in the full perfuafion that this food would be likely to increafe their own courage. They fcalp the vanquifhed as in Canada, and pluck out their eyes; which they have the art of preferving free from corruption, and which they carefully keep as precious figns of their victory. Their cuftom is to burn their dead, and to depofit their afhes in morais.

MOORS, in common language, are the natives of Morocco, of whom an account is given under that title in the *Encyclopædia*; but there is another people, a mixed race, called alfo Moors, who lead a wandering and paftoral life in the habitable parts of the Great Defert, and in the countries adjacent to it. Of the origin of thefe Moorifh tribes, as diftinguifhed from the inhabitants of Barbary, nothing farther feems to be known than what is related by John Leo the African; whofe account may be abridged as follows:

Before the Arabian conqueft, about the middle of the feventh century, all the inhabitants of Africa, whether they were defcended from Numidians, Phœnicians, Carthaginians, Romans, Vandals, or Goths, were comprehended under the general name of *Mauri*, or Moors. All thefe nations were converted to the religion of Mahomet, during the Arabian empire, under the Kaliphs. About this time many of the Numidian tribes, who led a wandering life in the defert, and fupported themfelves upon the produce of their cattle, retired fouthward acrofs the Great Defert, to avoid the fury of the Arabians; and by one of thofe tribes, fays Leo (that of Zanhaga), were difcovered, and conquered, the Negro nations on the Niger. By the Niger, is here undoubtedly meant the river of Senegal, which in the Mandingo language is called *Bafing*, or the Black River.

To what extent thefe people are now fpread over the African continent, it is difficult to afcertain. There is reafon to believe, that their dominion ftretches from weft to eaft, in a narrow line or belt, from the mouth of the Senegal (on the northern fide of that river) to the confines of Abyffinia. Mr Park defcribes them as refembling, in complexion, the Mulattoes of the Weft Indies, and as having cruelty and low cunning pictured in their countenances. "From the ftaring wildnefs in their eyes (fays he), a ftranger would immediately fet them down as a nation of lunatics. The treachery and malevolence of their character are manifefted in their plundering excurfions againft the Negro villages. Oftentimes, without the fmalleft provocation, and fometimes under the faireft profeffions of friendfhip, they will fuddenly feize upon the Ngroes cattle, and even on the inhabitants themfelves. Ths Negroes very feldom retaliate. The enterprifing boldnefs of the Moors, their knowledge of the country, and, above all, the fuperior fleetnefs of their horfes, make them fuch formidable enemies, that the petty Negro ftates, which border upon the defert, are in continual alarm while the Moorifh tribes are in the vicinity, and are too much awed to think of refiftance.

"Like the roving Arabs, the Moors frequently remove from one place to another, according to the feafon of the year, or the convenience of pafturage. In the month of February, when the heat of the fun fcorches up every fort of vegetation in the defert, they ftrike their tents, and approach the Negro country to the fouth; where they refide until the rains commence, in the month of July. At this time, having purchafed corn, and other neceffaries from the negroes, in exchange for falt, they again depart to the northward, and continue in the defert until the rains are over, and that part of the country becomes burnt up and barren.

"This wandering and reftlefs way of life, while it inures them to hardfhips, ftrengthens, at the fame time, the bonds of their little fociety, and creates in them an averfion towards ftrangers, which is almoft infurmountable. Cut off from all intercourfe with civilized nations, and boafting an advantage over the Negroes, by poffeffing, though in a very limited degree, the knowledge of letters, they are at once the vaineft and proudeft, and perhaps the moft bigotted, ferocious, and intolerant, of all the nations on the earth; combining in their character the blind fuperftition of the Negro with the favage cruelty and treachery of the Arab." But for them Mr Park would have accomplifhed the utmoft object of his miffion, and have reached Tombuctoo, and even Houffa, with no other danger than what arifes neceffarily from the climate, from wild beafts, and from the poor accommodation afforded in the huts of the hofpitable Negroes. The wandering Moors, however, have all been taught to regard the Chriftian name with inconceivable abhorrence; and to confider it nearly as lawful to murder a European as it would be to kill a dog. It is, therefore, much lefs furprifing that our traveller did not proceed farther along the banks of the Nigre, than that he efcaped the fnares of fo relentlefs a people.

MORINDA, is a plant, of which a very meagre defcription has been given in the *Encyclopædia*, though it is of much importance in oriental commerce. It is cultivated to a great extent in the province of *Maleva*, in the Eaft Indias, where it furnifhes a valuable dye-ftuff; and is thus defcribed by William Hunter, Efq; in the fourth volume of the Afiatic refearches:

"It is a tree of a middling fize; the *root* branchy; the *trunk* columnar, erect, covered with a fcabrous bark. *Branches*, from the upper part of the trunk, fcattered; of the ftructure of the trunk. *Leaves* (feminal) oval, obtufe, entire (mature), oppofite, decuffated, ovate, pointed at both ends, fmooth, with very fhort petioles. *Stipules*, lanced, very fmall, withering. *Peduncles*, from the axils of the leaves, folitary, bearing an aggregate flower. *Calyx*, common receptable roundifh, collecting the feffile flowers into an irregular head. *Perianth*, moft entire, fcarce obfervable above. *Coral*, one petalled, funnel-form. *Tube*, cylindric: *Border*, five cleft; the *divifions* lanced. *Stamen: Filaments*, five, threadform, arifing from the tube, and adhering to it through two thirds of their length, a little fhorter than the tube. *Anthers*, linear, erect. *Piftil. Germ*, beneath, four-celled, containing the rudiments of four feeds. *Style*, thread form, longer than the ftamens. *Stigma*, two cleft, thickifh. *Pericarp*, common, irregular, divided on the furface into irregular angular fpaces; compofed of berries, pyramidal, compreffed on all fides by the adjacent ones, and concreted with them; lopped; containing towards the bafe a flefhy pulp. *Seeds*, in each berry four; towards the point oblong, externally convex, internally angular."

The

The fpecies here defcribed is the *morinda arborea pedunculis folitariis* of Linnæus. It grows beft in a black rich foil, free from ftones, in fituations moderately moift, not too high, yet fufficiently elevated to prevent the rain water from ftagnating, and where a fupply of water can be had for the dry months. As the colouring matter, for which alone it is valuable, refides chiefly in the bark of the root, the fmall twigs, which contain little wood, bear a higher price than the larger pieces. The natives employ it in dyeing a pale red, or clay colour; which Mr Hunter fays is more valuable for its durability than for its beauty. They likewife ufe it in dyeing a dark purple or chocolate colour; but for the procefs, in both cafes, we muft refer to the original memoir.

MORION, in botany, a name given by the ancients to a kind of nightfhade. See Solanum, *Encycl.*

Morion, in ancient mineralogy, a name given to one of the femipellucid gems, more commonly called *pramnion*. It is a ftone appearing externally of a fine deep black; but when held up againft a candle, or againft the fun-beams, it gives a very beautiful red in different degrees.

MOSHAIRA, or Moshahereh, penfion or allowance in Bengal.

MOSS, the name given in Scotland, and we believe alfo in fome parts of England, to what is more properly called a *morafs*, a *fen*, or a *bog*. On the formation of thefe moffes fome conjectures have been hazarded in the *Encyclopædia*, where the reader will likewife find a copious account of the method which has for many years been fuccefsfully employed to convert the Moss of Kincardine into an arable foil, or rather to remove the fubftance called *mofs* or *peat* from the rich foil which is found below it. A method, however, has been invented by Mr John Smith of Swindrig-muir, in the fhire of Ayr, for *actually* converting the fubftance called mofs into a vegetable mould, which has been found by experience to carry rich crops of corn, hay, potatoes, &c. Of this gentleman's practice we have the following account in a fmall pamphlet publifhed in Edinburgh, 1798, by Fairbairn and Dickfon.

" The firft thing to be done is to mark off, and cut out, proper main or mafter drains, in order to carry off the fuperfluous water, taking care to preferve the greateft poffible level; which drains are fo conftructed as to divide the field into inclofures from fix to ten Scotch acres. If the mofs hangs or declines, the inclofures may be of any dimenfion whatever. The dimenfions of thefe drains when firft made are eight feet wide, by four and a half feet deep, declining to two and a half feet at bottom, and coft at the rate of one fhilling per fall of eighteen and a half feet, running meafure. The ridges are then to be marked off regularly, fix or feven yards broad, formed with the fpade in the manner following:

" In the centre of each ridge, a fpace of about 20 inches is allowed to remain untouched, on each fide of which a furrow is opened, and turned upon the untouched fpace, fo as completely to cover it (like what is called the feering of a gathered ridge). Thus begun, the work is continued, by cutting with the fpade, in width about 12 inches, and turning it over to appearance as if done with a plough, until you come to the divifion furrow, which fhould be two feet wide, cut out and thrown upon the fides of the ridges. The depth of the divifion furrow is to be regulated by circumftances, according as the mofs is wet or dry, but fo as to anfwer the purpofe of as it were bleeding the mofs, and conducting the water to the main drains.

" It may be here obferved, that the fuccefs of the aftercrops depends very much upon a proper formation of the ridges. They muft not be made too high in the middle, for there they will be too dry like a peat, upon which the lime cannot act, and near the furrows they will be too wet, which is equally prejudicial; they fhould therefore be conftructed with a gentle declivity to the furrows, fo as the rain which falls may rather filtrate through the ridge to the furrows than run quickly off the furface.

" The next operation is to top drefs the ridges with lime, at the rate of from four to eight chalders per acre. Five Winchefter bufhels make a boll, and eight bolls a chalder of fhell lime, producing fixteen bolls powdered lime. The quicker the lime is put on after being flacked the better.

" The proper feafon to prepare the mofs for a firft crop is early the preceding fummer; in that cafe the lime, aided by the heat, the after rains, and the winter frofts, makes confiderable progrefs in the procefs of putrefaction, confequently forms a mould to receive the feed.

" Though oats have fometimes fucceeded as a firft crop, potatoes have been found greatly preferable. The method of planting them is fimple, and attended with little expence. The mofs, prepared by ridges, and limed as before defcribed, beds for the potatoes are, in the fpring, marked off, acrofs the ridges, five or fix feet broad, with intermediate fpaces of about two feet, as furrows or trenches. The beds are covered over with a thin ftratum of dung, about eighteen fingle-horfe carts to an acre, the cuttings of the potatoes are laid or placed upon the beds, about ten or twelve inches afunder, and the whole covered over with a thin ftratum of mofs from the intermediate trenches, which is followed by another covering from the trenches when the potatoe plants make their firft appearance; the covering in whole four or five inches. In this ftate they remain without any hoeing till the crop is taken up. The produce on Mr Smith's mofs has never been lefs than from forty to fifty bolls of excellent potatoes, eight Winchefter bufhels to the boll, and the bufhel a little heaped.

" When the potatoe crop is removed, the ridges are again formed as before defcribed, and the divifion furrow cleared out. In performing this part of the work, it will naturally occur, that a great part of the manured furface will be buried in filling up the trenches between the potatoe beds: but that is not the cafe; the workman makes two cuts with the fpade, at eighteen inches diftance, upon the fide of the trench; another, one foot from the edge of it, as deep as the trench; which, inftead of turning over, he preffes a foot forward into the trench, which is continued the length of it; and when he comes to the other fide he does the fame, making both meet, and fo proceeds; fo that no part of the manured furface is thrown down, and the ridge is left in the fame form as before the lazy-beds* were made.

" When the potatoe crop is taken off, and the ridges formed as before defcribed, they remain in that ftate till fpring, when oats are fown (a wet or dry feafon has from

* This is a vulgar Scottifh phrafe for beds of a particular kind of potatoe.

from experience been found a matter of indifference), and harrowed in with a fmall harrow drawn by two men. Four men with eafe harrow at leaft one acre one rood per day, two and two by turns with the harrow, and the other two in the interim with fpades, fmoothing the inequalities, breaking and dividing the mould, and clearing out the divifion furrows; which laft in all operations upon mofs are effentially neceffary. The early or hot feed oats are always preferred for feed. The late or cold feed runs too much to ftraw, falls down, and becomes floomy, confequently the grain is of mean quality, and unproductive in meal.

"The produce of the firft crop of oats after potatoes is feldom lefs than ten bolls per acre, the Linlithgow boll of fix Winchefter bufhels, and confiderably more has been known; as good grain in quality, and meals as well as any in the country. It has been fold when growing, what is called upon the foot, including the ftraw, from eight to ten pounds per acre. To prepare for a fecond crop of oats, the ridges muft be dug acrofs, and turned over in the manner before defcribed, and the divifion furrows cleared out as foon as convenient after the firft crop is removed.

"Such is the effect of lime in confolidating mofs, aided by the draining, that often after the fecond, and always after the third year, it can be ploughed by horfes within two bouts or ftitches of the divifion furrow; and alfo harrowed by horfes, and the crops taken off by carts.

"Five and often fix confecutive crops of oats are taken, without any other manure than what it received the firft year for potatoes, without any apparent figns of it being exhaufted. The produce of the firft two crops of oats has been mentioned to be ten bolls, and the third, fourth, fifth, and fixth, produce from fix to ten bolls per acre. The mofs is now turned into a feeming rich dark brown mould; and what renders it lefs productive of corn crops the fourth, fifth, and fixth years is, its naturally running into fweet and luxuriant graffes. The foft meadow grafs, the daify, fome plaintain, but principally the white clover, are the moft prevalent graffes; or more probably it may be afcribed to thefe crops being ploughed, in place of being dug with the fpade, as the former years were. Along with the fifth or fixth crop of oats, rye grafs is fown, which, with the natural graffes in general, produce an abundant crop of hay.

"If the mofs in the original ftate has been wet and fpongy, it will be found to have fubfided fome feet after the third or fourth year's operation has been performed; but care muft always be taken to deepen, clear out, and keep clear the main drains and the divifion furrows, to prevent a fuperabundance of moifture, which would infallibly be the cafe were they neglected in confequence of the fubfidence of the mofs. Indeed mofs of all forts will fubfide lefs or more, in proportion as it has been dry or wet in its original ftate; at the fame time, as ftated before, care muft be taken not to lay it too dry, but to keep in a proper degree of temperature between thefe two extremes."

By having recourfe to the pamphlet from which this extract has been made, the reader may fatisfy himfelf of the real advantages of this fpecies of agriculture. The author calculates, with much apparent fairnefs, the expence of improvement, and the value of each crop, and concludes that no wafte can be improved with equal advantage as mofs. It muft not, however, be concealed, that we have heard practical farmers, who feemed to be acquainted with the fubject, give it as their opiuion that this mode of cultivation anfwers only in moffes of no great depth; though our author affirms that it has with great fuccefs been practifed by Mr Smith in moffes of the depth of 14 feet.

MOTION IN FLUIDS. When in the publication of this *Supplement* we had arrived at the title FLUIDS, we were ftruck with the importance given, in fome of the journals, to *The Experimental Refearches of* Venturi *concerning the Principle of the lateral communication of Motion in Fluids, applied to the Explanation of various Hydraulic Phenomena.* Of thefe refearches we intended to lay an abridged account before our readers under the prefent title; but having examined the work with fome attention, we find in it hardly any thing of confequence which the mechanical philofopher may not learn from our articles *RESISTANCE of Fluids* and RIVER in the *Encyclopædia*. That our readers, however, may find fomething under a title to which we rafhly referred them, we fhall, in the words of Nicholfon's Journal of Natural Philofophy, &c. inform them what Venturi's work contains.

"This author, who is profeffor of experimental philofophy at Modena, has introduced an horizontal current of water into a veffel filled with the fame fluid at reft. This ftream entering the veffel with a certain velocity, paffes through a portion of the fluid, and is then received in an inclined channel, the bottom of which gradually rifes until it paffes over the border or rim of the veffel itfelf. The effect is found to be, not only that the ftream itfelf paffes out of the veffel through the channel, but carries along with it the fluid contained in the veffel; fo that after a fhort time no more of the fluid remains than was originally below the aperture at which the ftream enters. This fact is adopted as a principle or primitive phenomenon by the author, under the denomination of the lateral communication of motion in fluids, and to this he refers many important hydraulic facts. He does not undertake to give an explanation of this principle, but fhews that the mutual attraction of the particles of water is far from being a fufficient caufe to account for it.

The firft phenomenon which the author propofes to explain by this eftablifhed principle, is the emiffion of a fluid through different adjutages applied to the refervoir which contains it. It is known that the vein of fluid which iffues from an orifice or perforation through a thin plate, becomes contracted, fo as to exhibit a fection equal to about 0,64 of the orifice itfelf, fuppofed to be circular; and that the place of the greateft contraction is ufually at the diftance of one femi-diameter of the orifice itfelf. If a fmall adjutage be adapted to the orifice, having its internal cavity of the fame conoidal form as the fluid itfelf affects in that interval, the expenditure is the fame as by the fimple orifice. But if at the extremity of this adjutage a cylindric tube be affixed, of a greater diameter than that of the contracted vein, or a divergent conical tube, the expence of fluid increafes, and may exceed the double of that which paffes through the aperture in the thin plate, though the adjutage poffefs an horizontal or even afcending direction.

By

By the interpofition of a fmall adjutage, adapted to the form of the contracted vein, Venturi afcertained, in the firft place, that there is an increafe of velocity in the tubes he employed, though the velocity of emiffion itfelf be lefs than that of the ftream which iffues from a hole in a thin plate. He afterwards proves, by the fact, that the interior velocity and expenditure of fluid, which is increafed through tubes, even in the horizontal or afcending direction, is owing to the preffure of the atmofphere. If the fmalleft hole be made in the fide of the tube near the place of contraction of the vein, the increafed expenditure does not take place; and when a verticle tube is inferted in fuch a hole, the lower end of which tube is immerfed in water or mercury, it is found that afpiration takes place, and the water or mercury rifes; and this afpiration in conical tubes is lefs in proportion, as the place of infertion of the upright tube is more remote from the fection where the greateft contraction would have taken place. And, laftly, the difference between the expenditure of fluid, through an orifice made in a thin plate, and that which is obferved through an additional tube, does not take place in vacuo.

The influence of the weight of the atmofphere on the horizontal or afcending flux being thus eftablifhed, the author confiders it as a fecondary caufe, referable to, and explicable by, his principle of the lateral communication of motion in fluids. In conical divergent tubes, for example, the effect of this lateral communication is, that the central cylindrical jet, having for its bafis the fection of the contracted vein, carries with it the lateral fluid which would have remained ftagnant in the enlarged part of the cone. Hence a vacuum tends to be produced in this enlarged part which furrounds the central cylindric ftream; the preffure of the atmofphere becomes active to fupply the void, and is exerted on the furface of the refervoir, fo as to increafe the velocity of the fluid at the interior extremity of the tube.

The author proves, that the velocity or total expenditure of fluid through an aperture of given dimenfions, may be increafed by a proper adjutage in the proportion of 24 to 10; he applies this refult to the conftruction of the funnels of chimneys. He determines the lofs of emitted fluid, which may be fuftained by finuofity in pipes. He fhews by experiment, that a pipe which is enlarged in any part affords a much lefs quantity of fluid than if it were throughout of a diameter equal to that of its fmalleft fection. This, as he remarks, is a circumftance to which fufficient attention has not been paid in the conftruction of hydraulic machines. It is not enough to avoid elbows and contractions; for it fometimes happens that, by an intermediate enlargement, the whole of the advantage arifing from other judicious difpofitions of the parts of the machine is loft.

There are two cafes of the increafe of expenditure through defcending pipes. The firft is owing to the lateral communication of motion which takes place in defcending pipes, in the fame manner as in thofe which poffefs an horizontal fituation; the fecond arifes from the acceleration by gravity which takes place in the fluid while it falls through the defcending tube. This fecond kind of augmentation was known to the ancients, though they poffeffed no good theory nor decifive experiments refpecting it. The author endeavours to eftablifh a theory on the principle of virtual afcenfion combined with the preffure of the atmofphere. His deductions are confirmed by experiment, in which he has fucceeded fo far as to feparate the two caufes of augmentation, and affigned to each their refpective degree of influence.

Profeffor Venturi then proceeds to different objects of enquiry, to which his principle feemed applicable. He gives the theory of the water-blowing machine (fee *Water Blowing Machine* in this *Suppl.*), and he determines by calculation the quantity of air which one of thefe machines can afford in a given time. He obferves, that the natural falls of water in the mountains always produce a local wind; and he even thinks, that the falling ftreams in the internal parts of mountains are in fome inftances the caufe of the winds which iffue from caves. He proves, by the facts, that it is poffible, in certain inftances, to carry off, without any machinery, the waters from a fpot of ground, though it may be fituated on a lower level than that of the channel which is to receive the water.

The whirlpools, or circular eddies of water fo frequent in rivers, are, according to the theory of our author, the effect of motion communicated from the parts of the current which are moft rapid, to thofe lateral parts which are leaft fo. In the application of this principle, he points out the circumftances adapted to produce fuch eddies at the furface or at the bottom of rivers. He concludes, that every movement of this kind deftroys a part of the force of the current, and that in a channel through which water conftantly flows, the height of this fluid will be greater than it would have been if the dimenfions of the channel had been uniformly reduced to the meafure of its fmalleft fection.

There is another kind of whirling motion fomewhat different in its nature from thefe laft. It is produced in the water of a refervoir, when it is fuffered to flow through an horizontal orifice. The author deduces the theory of thefe vortices from the doctrine of central forces. The form of the hollow funnel, which in this cafe opens through the fluid of the refervoir, is a curve of the 64th fpecies of the lines of the third order, enumerated by Newton. Theory and experiment both unite here in proving, that it is not only poffible, but that there really exifts in nature a vortex, the concavity of which is convex towards the axis, and of which the revolutions of its different parts follow the ratio of the fquare of the diftance from the centre. Daniel Bernoulli was in the wrong, in his Hydrodynamics, to reproach Newton for having fuppofed a vortex to be moved according to this law.

In the laft place, the author confiders that lateral communication of motion which takes place in the air as well as in the water. This is the caufe of fuch local and partial winds as fometimes blow contrary to the direction of the general wind. It is by virtue of the fame principle, that the refonant vibration, excited laterally in the extremity of an organ-pipe, is communicated to the whole column of air contained in the pipe itfelf.

From the fame principle, the author deduces the augmentation of force which found receives in conical divergent tubes, compared with thofe of a cylindrical form. On this occafion, he points out the remarkable diffe-

differences which appear to take place between the resonant vibrations of air contained in a tube, and the sonorous pulsations propagated through the open atmosphere. See *Speaking Trumpet*, Encycl.

In an appendix, Venturi relates different experiments which he has made to determine the convergence and velocity of the fluid filaments which press forward to issue out of a reservoir by an orifice through a thin plate. He proves, by a very clear experiment, that the contraction of the vein is made at a greater distance from the orifice under strong than under weak pressures. He explains why, in a right-lined orifice, the sides of the contracted vein correspond with the angles of the orifice and the angles with the sides. He examines the expenditure through a tube, the extremity of which is thrust into the reservoir itself, according to the method of Borda in the Memoirs of the Academy of Sciences for the year 1766."

For a full account of the author's experiments, and his deductions from them, we refer the reader either to the original work, intitled, *Recherches expérimentales sur le Principe de la Communication latérale du Mouvement dans les Fluides, appliqué à l'Explication de différens Phénoménes hydrauliques. Par le Citoyen J. B. Venturi, Professeur de Physique expérimentale à Modène, Membre de la Société Italienne, &c. &c. A Paris chez Houel et Ducros, Rue du Bacq*, No. 940—*Théophile Barrois, Rue Haute feuille*, N. 22. *Ann.* VI. 1797—or to the 2d and 3d vols of the valuable Journal from which this abstract is taken.

MOURZOUK, the capital of Fezzan in Africa, is situated on a small river, and supplied with water from multitudes of springs and wells. Being formerly built of stone, it still retains the appellation of a Christian town; and the medley which it presents to the eye, of the vast ruins of ancient buildings, and the humble cottages of earth and sand that form the dwellings of its present Arab inhabitants, is singularly grotesque and strange. It is surrounded by a high wall, which not only affords the means of defence, but enables the government to collect, at its three gates, a tax on all goods (provisions excepted) that are brought for the supply of its people. A caravan sets out annually from Mesurata to this place; and hence the Fezzaners themselves dispatch every year a caravan to Cashna and another to Bornou. For the lătitude of Mourzouk, see Fezzan in this *Suppl.* Dr Brookes, in his Gazetteer, places it in 15° 5′ E. Long.

MOWAZZEF, in Bengal, fixed revenue.

MOZART, the celebrated German musician, was born at Salzburg in the year 1756. His father was also a musician of some eminence, but not to be compared with the son; of whom we have the following account in one of the monthly miscellanies, taken by Mr Bushby from some biographical sketches by two eminent German professors,

At the age of three years, young Mozart, attending to the lessons which his sister, then seven years old, was receiving at the herpsichord, he became captivated with harmony; and when she had left the instrument, he would instantly place himself at it, find the thirds, found them with the liveliest joy, and employ whole hours at the exercise. His father, urged by such early and striking indications of genius, immediately began to teach him some little airs; and soon perceived that his pupil improved even beyond the hopes he had formed of him. Half an hour was generally sufficient for his acquiring a minuet or a little song, which, when once learned, he would of himself perform with taste and expression.

At the age of six years he had made such a progress as to be able to compose short pieces for the harpsichord, which his father was obliged to commit to paper for him. From that time nothing made any impression upon him but harmony; and infantine amusements lost all their attractions unless music had a share in them. He advanced from day to day, not by ordinary and insensible degrees, but with a rapidity which hourly excited new surprise in his parents—the happy witnesses of his progress.

His father returning home one day with a stranger, found little Mozart with a pen in his hand. "What are you writing," said he? "A concerto for the harpsichord," replied the child. "Let us see it (rejoined the father); it is a marvellous concerto without doubt." He then took the paper, and saw nothing at first but a mass of notes mingled with blots of ink by the mal-address of the young composer, who, unskilled in the management of the pen, had dipped it too freely in the ink; and having blotted and smeared his paper, had endeavoured to make out his ideas with his fingers; but on a closer examination his father was lost in wonder; and his eyes delighted and flowing with tears, became rivetted to the notes. "See (exclaimed he to the stranger) how just and regular it all is! but it is impossible to play it; it is too difficult." "It is a concerto (said the child), and must be practised till one can play it. Hear how this part goes." He then sat down to perform it; but was not able to execute the passages with sufficient fluency to do justice to his own ideas. Extraordinary as his manual facility was universally allowed to be for his age, it did not keep pace with the progress of his knowledge and invention. Such an instance of intellectual advancement, in a child only six years of age, is so far out of the common road of nature, that we can only contemplate the fact with astonishment, and acknowledge, that the possible rapidity of mental maturation is not to be calculated.

In the year 1762, his father took him and his sister to Munich, where he performed a concerto before the elector, which excited the admiration of the whole court; nor was he less applauded at Vienna, where the emperor called him the *little sorcerer*.

His father gave him lessons only on the harpsichord; but he privately taught himself the violin; and his command of the instrument afforded the elder Mozart the utmost surprise, when he one day at a concert took a second violin, and acquitted himself with more than passable address. True genius sees no obstacles. It will not therefore excite our wonder, if his constant succees in whatever he attempted begot an unbounded confidence in his own powers; he had even the *laudable* hardihood to undertake to qualify himself for the *first* violin, and did not long remain short of the necessary proficiency.

He had an ear so correct, that he felt the most minute discordancy; and such a fondness for study, that it was frequently necessary to take him by force from the instrument. This love of application never diminished. He every day passed a considerable time at his harpsichord, and generally practised till a late hour at night.

Mozart night. Another characteriftical trait of real genius; always full of its object, and loft as it were in itfelf.

In the year 1763 he made, with his father and fifter, his firft grand mufical journey. He vifited Paris; and was heard by the French court in the chapel-royal at Verfailles, where his talent on the organ was admired even more than on the harpfichord. At Paris the mufical travellers gave two concerts, which procured them the higheft reputation, and the diftinction of public portraits. It was here that a fet of fonatas for the harpfichord, fome of his earlieft compofitions, were engraved and publifhed.

From Paris they went to London, where they alfo gave two concerts, confifting of fymphonies compofed by young Mozart, who even at that early age fang alfo with much expreffion, and practifed publicly with his fifter. Mozart played already at fight, and in a concert, at which the king was one of his auditors, a bafs being placed before him as a *ground*, immediately applied to it a moft beautiful melody. Thofe who are beft acquainted with the extent of fuch a tafk, will be the moft aftonifhed at fuch mature familiarity with the intricacies of the fcience, and fuch prompt and ready invention in fo juvenile a mind.

From London, where Mozart alfo publifhed fix fonatas for the harpfichord, the mufical family went to Holland, thence again to France, and in 1766 returned to Salzburg. There this extraordinary youth remained more than a year in perfect repofe; devoting the whole of his time to the ftudy of compofition, the principles of which he fcrutinized with the depth and penetration of confirmed manhood. Emmanuel Bach, Haffe, and Handel, were his chief guides and models; though he by no means neglected the old Italian mafters.

In 1768 he again vifited Vienna, where Jofeph II. engaged him to fet to mufic a comic opera, entitled, *La Finta Semplice*, which obtained the approbation of Haffe and Metatafio. At the houfe of the prince of Kaunitz, it often happened that the firft Italian air which came to hand would be given him, that in the prefence of the company he might add to it accompaniments for numerous inftruments; which he would write in the firft ftyle of excellence, and without the leaft premeditation. This is at once a proof with what acutenefs of obfervation he had liftened to the mufic of the beft mafters; how intimate he had already rendered himfelf with the characters, capacities, and effects of the different inftruments; and what fkill he had acquired in that abftrufe art of mixed combination which, while it calculates the conjoint effect of founds, as they regard the eftablifhed laws of harmony, accommodates the different parts to the fcales, tones, and powers of the refpective inftruments by which they are to be executed. It was at this time alfo that, although but twelve years of age, he compofed the mufic for the confecration of the church of orphans, at the performance of which he himfelf prefided.

In 1769 Mozart again returned to Salzburgh, where he became *maitre de concert*. Not having yet feen Italy, in December of the fame year he fet out for that feat of the fine arts. Thofe talents which had already excited the admiration of Germany, France, and England, now awakened in that land of mufical tafte the moft lively enthufiafm.

In 1771 he had no fooner given perfonal proofs of his genius, than *la fcrittura* for the following carnival was conferred upon him. He vifited Bologna, then as famous for harmonic excellence as Naples, where the celebrated theorift Martini was amazed to fee a German boy work and execute the theme of a fugue which he prefented to him, in the extraordinary ftyle in which Mozart acquitted himfelf. He next went to Florence. Florence even enhanced the eulogiums which Bologna had lavifhed upon him.

During the holy week he arrived at Rome, and affifted at the *Miferere* in the Sixtine chapel; which performance is juftly confidered as the *ne plus ultra* of vocal mufic. This circumftance claims particular notice, as inducing a proof of another faculty of his mind, only to be equalled by thofe wonderful powers which he had already demonftrated. He was prohibited from taking a copy of this *Miferere*, and therefore piqued himfelf on retaining it in his memory. Having heard it with attention, he went home, made out a manufcript from recollection, returned the next day to the chapel, heard the piece a fecond time, corrected the rough draught, and produced a tranfcript which furprifed all Rome. This *Miferere* formed a *fcorer* numerous in its parts, and extremely difficult of execution. His mind had embraced and retained the whole!

He foon after received from the Pope the order of the gilt fpur; and at Bologna was complimented, by an unanimous decifion, with the title of *Member and Mafter of the Phil-harmonic Academy*. As a proof, *pro forma*, of his qualifications for this academical honour, a fugue, for four voices, in the church ftyle, was required of him, and he was fhut up alone in his chamber. He completed it in half an hour, and received his diploma. This evinced that he poffeffed an imagination conftantly at his command, and that his mind was ftored with all the riches of his beloved fcience.

The opera which he compofed for Milan was called *Mithridates*. This piece procured him *la fcrittura* for the grand opera of the carnival of 1773, which was his *Lucio Sulla*. At length, after a tour of fifteen months, he returned to Salzburgh.

In 1771 Mozart vifited Paris; but not relifhing the mufic of that capital, he foon quitted it, and returned to his domeftic comforts. In 1781, at the requeft of the elector of Bavaria, he compofed the opera of *Idomeneo* for the carnival of that year. The general merit of this opera is fo great, that it might ferve for the bafis of a diftinguifhed reputation. At his twenty-fifth year he was invited to Vienna, where he continued fpreading, as from a centre, the tafte of his compofitions through all Germany, and the luftre of his name over the whole of Europe.

Of all the virtuofi of the piano forte who then crowded Vienna, Mozart was much the moft fkilful. His finger was extraordinarily rapid and tafteful, and the execution of his left hand exceeded every thing that had before been heard. His touch was replete with delicacy and expreffion; and the profound ftudy he had beftowed on his art, gave his performance a ftyle the moft brilliant and finifhed. His compofitions had a rapid circulation; and every new piece the connoiffeurs were ftruck with the originality of its caft, the novelty of the paffages, and the energy of the effect.

Jofeph II. folicitous for the perfection of the German opera, engaged Mozart to compofe a piece. He accordingly

Mozart. cordingly produced *L'enlevement du Serail;* performed for the firſt time in 1782. It excited the jealouſy of the Italian company, who therefore ventured to cabal againſt it. The emperor, addreſſing himſelf to the compoſer, ſaid, "It is *too fine* for our ears, my dear Mozart, and moſt *charmingly crowded* with notes." "Preciſely what it ought to be," replied the ſpirited muſician, who juſtly ſuſpected that this remark had been ſuggeſted to Joſeph by the envious Italians. "Though I cannot deſcribe, as an auricular evidence, (ſays the faithful author of the biography), the applauſes and the admiration which this opera produced at Vienna, yet I have witneſſed the enthuſiaſm it excited at Prague among all the connoiſſeurs, as well as among thoſe whoſe ears were leſs cultivated. It was ſaid, that all which had been heard before was not muſic: it drew the moſt overflowing audiences: every body was amazed at its new traits of harmony, and at paſſages ſo original, and till then ſo unheard from wind inſtruments."

The cautious reader will perhaps heſitate to admit, in its fulleſt extent, this account by the author of the biography; but even after an allowance for ſome exaggeration, the moſt phlegmatic will grant that much muſt have been atchieved by this great maſter, to afford a baſis for ſo glowing a picture of the merit and ſucceſs of *L'enlevement du Serail.* During the compoſition of this opera, he married Mademoiſelle Weber, a diſtinguiſhed virtuoſa; and the piece was ſuppoſed to owe to this felicitous circumſtance much of that endearing character, that tone of tenderneſs, and that expreſſion of the ſofter paſſions, which form its principal attractions.

"The Marriage of Figaro," which was in the higheſt repute at all the theatres, was in the year 1787 transformed into an Italian opera; and Mozart, at the inſtance of the emperor, ſet it to muſic. This piece was highly received everywhere, and kept poſſeſſion of the theatre at Prague during almoſt the whole of the winter in which it firſt appeared: numerous extracts were made from it, and the ſongs and dances of Figaro were vociferated in the ſtreets, the gardens, and the taverns. Mozart came that very winter to Prague, and performed in public on the piano forte. His auditors at all times liſtened to him with admiration; but whenever he played extempore, and indulged the ſpontaneous and uninterrupted ſallies of his fancy, which he ſometimes would for more than half an hour, every one was ſeized with the moſt enthuſiaſtic raptures, and acknowledged the unrivalled reſources of his imagination. About this time the manager of the theatre contracted with him for the compoſition of a new opera, which, when produced, was called *Il diſſoluto Punito,* or *Don Giovanni.* His reputation was now ſo exalted, that the Bohemians piqued themſelves on the circumſtance that this opera was compoſed for their entertainment.

But this fame, this great and univerſal applauſe, had not yet produced to the admired artiſt any ſolid advantages; he had obtained no place, no ſettled income; but ſubſiſted by his operas, and the inſtructions and occaſional concerts which he gave. The profits of theſe proved inſufficient for the ſtyle which he was obliged to ſupport; and his finances became much deranged. The critical ſituation in which he now found himſelf, made him reſolve to quit Vienna, and ſeek an aſylum in London; to which metropolis he had often been invited; but Joſeph nominating him *compoſiteur de la chambre,* though, with a very inadequate ſalary, he was induced to accept it; and Germany had the advantage of retaining him.

It is lamentable that premature genius too rarely enjoys a long career: The acceleration of nature in the mental powers ſeems to hurry the progreſs of the animal œconomy, and to anticipate the regular cloſe of temporal exiſtence.

In the year 1791, Mozart, juſt after he had received the appointment of *Maitre de chapelle* of the church of St Peter, and when he was only thirty five years of age, paid the laſt tribute; and left the world at once to admire the brilliancy, and lament the ſhortneſs of his earthly ſojournment.

Indefatigable, even to his death, he produced, during the laſt few months of his life, his three great maſter pieces *La Flutte Enchantée, La Clemence de Titus,* and a *Requiem,* his laſt production. *La Flutte Enchantée* was compoſed for one of the theatres at Vienna; and no dramatic *Olio* could ever boaſt a greater ſucceſs. Every air ſtruck the audience with a new and ſweet ſurpriſe; and the *tout enſemble* was calculated to afford the deepeſt and moſt varied impreſſions. This piece had, in fact, ſo great a number of ſucceſſive repreſentations, that for a long time it was unneceſſary to conſult the opera-bill; which only announced a permanent novelty. And the airs ſelected from it, and repeated throughout the empire, as well in the cottage as in the palace, and which the echoes have reſounded in the moſt diſtant provinces, favoured the idea that Mozart had actually the deſign to enchant all Germany with his *Flutte Enchantée.*

La Clemence de Titus was requeſted by the ſtates of Bohemia for the coronation of Leopold. The compoſer began it in his carriage during his route to Prague, and finiſhed it in eighteen days.

Some circumſtances attending the compoſition of the piece which we have already mentioned as the laſt effort of his genius, are too intereſting to be omitted. A ſhort time before his death, a ſtranger came to him with the requeſt that he would compoſe, as ſpeedily as poſſible, a *requiem* for a catholic prince, who, perceiving himſelf on the verge of the grave, wiſhed, by the execution of ſuch a piece, to ſooth his mind, and familiariſe it to the idea of his approaching diſſolution. Mozart undertook the work; and the ſtranger depoſited with him as a ſecurity 400 ducats, though the ſum demanded was only 200. The compoſer immediately began the work, and during its progreſs felt his mind unuſually raiſed and agitated. He became at length ſo infatuated with his *requiem,* that he employed not only the day, but ſome hours of the night in its compoſition. One day, while he was converſing with Madame Mozart on the ſubject, he declared to her that he could not but be perſuaded that it was for himſelf he was writing this piece. His wife, diſtreſſed at her inability to diſſipate ſo melancholy an impreſſion, prevailed on him to give her the *ſcore.* He afterwards appearing ſomewhat tranquillized, and more maſter of himſelf, ſhe returned the *ſcore* to him, and he ſoon relapſed into his former deſpondency. On the day of his death he aſked for the *requiem,* which was accordingly brought to his bed: "Was I not right (ſaid he), when I declared that it

was

Mozart. was for myfelf I was compofing this funeral piece?" And the tears trickled from his eyes. This production of a man, impreffed during its compofition with a prefentiment of his approaching death, is *unique* in its kind, and contains paffages which have frequently drawn tears from the performers.

Only one complaint efcaped him during his malady: "I muft quit life (faid he), precifely at the moment when I could enjoy it, free from care and inquietude; at the very time when, independent of fordid fpeculations, and at liberty to follow my own principles and inclinations, I fhould only have to write from the impulfes of my own heart: and I am torn from my family juft when in a fituation to ferve it." Mozart, at the time of his death, was confiderably involved in debt; but Vienna and Prague difputed the honour of providing for his widow and children.

The countenance of this great mafter did not indicate any thing uncommon. He was fmall of ftature; and, except his eyes, which were full of fire, there was nothing to announce fuperiority of talent. His air, unlefs when he was at the harpfichord, was that of an abfent man. But when he was performing, his whole phyfiognomy became changed: a profound ferioufnefs recalled and fixed his eyes; and his fentiments were expreffed in every movement of his mufcles. Never has a mufician more fuccefsfully embraced the whole extent of his art, and fhone with greater luftre in all its departments. His great operas, no lefs than his moft fimple fongs; his learned fymphonies as well as his airy dances—all carry the ftamp of the richeft imagination, the deepeft fenfibility, and the pureft tafte. All his works develope the originality of his genius; and imply a mind great and exalted; an imagination which ftrikes out for itfelf a new courfe. He therefore merits to be ranked with that fmall number of original geniufes, thofe *phænomena fplendida*, who form an epoch in their art, by carrying it to perfection, or giving it an unknown career.

It is in the employment of wind inftruments that Mozart difplays his greateft powers. His melody is always fimple, natural, and full of force; and expreffes with precifion the fentiments and individual fituations of his perfonages. He wrote with extraordinary facility. "*La Clemence de Titus*," the reader will recollect, coft him the ftudy of but eighteen days; and his *requiem*, which is equal in length to an opera, was produced in four weeks. It is alfo worthy of remark, that the overture to his *Don Giovanni* was not begun till the night before the piece was to be performed. At midnight, after having devoted the evening to amufement, he locked himfelf up in his ftudy, and compofed it in a few hours. His memory was wonderfully retentive, as we may judge from his copying by recollection the *miferere* at Rome. But a fact equally aftonifhing is, that, foon difcovering the eagernefs of people to procure his works, and fearful that they might be pirated, it was his conftant cuftom to tranfcribe from the *fcores* of his fonatas only a part for one hand, and at the public performance to fupply the other by memory.

He very early began to difplay that true dignity of an artift which renders him indifferent to the praifes of thofe who are unqualified to judge. The commendations of the ignorant great he never confidered as fame. His hearers, whether the wealthy or the titled, muft have acquired fome credit for their judgment before he could be ambitious of their applaufe. Indeed he entertained fo juft a fenfe of fcientific elevation and importance, that he would infift upon refpect. And the leaft noife or idle babble, while he was at the inftrument, excited a difpleafure which he was too indignant to conceal. Once, to the honour of his feelings, he fuddenly rofe from his feat, and left his inattentive auditory to experience the keen though filent reproach of infulted genius.

His mind was by no means unlettered; not was it embellifhed with one fcience alone. He was mafter of feveral languages, and had made confiderable progrefs in the mathematics. He was honeft, mild, generous, full of franknefs; and with his friends had an air at once amiable, gay, and free from the leaft tincture of pedantry.

Far from viewing with envy the fuccefs of others, a weaknefs too clofely interwoven in the general nature of man, he was always juft to the talents of his fellow profeffors; and valued and refpected merit wherever he found it; a clearer proof of which cannot be adduced than the following circumftance: At a concert, where a new piece compofed by the celebrated Jofeph Haydn was performed, a certain mufician, who never difcovered any thing worthy of praife except in his own productions, did not fail to criticife the mufic; exclaiming to Mozart, "There now! there again! why, that is not what *I* fhould have done:" "No; neither fhould I (replied Mozart); but do you know why? Becaufe neither you nor I fhould have been able to conceive it."

Mumbo. MUMBO-JUMBO, a ftrange bugbear employed by the Pagan Mandingoes (fee MANDING, *Suppl.*) for the purpofe of keeping their women in fubjection. Polygamy being allowed among thefe people, every man marries as many wives as he can conveniently maintain; and the confequence is, that family quarrels fometimes rife to fuch a height, that the hufband's authority is not fufficient to reftore peace among the ladies. On thefe occafions, the interpofition of *Mumbo-Jumbo* is called in; and it is always decifive. This ftrange minifter of juftice, who is either the hufband himfelf, or fome perfon inftructed by him, difguifed in a fort of mafquerade habit, made of the bark of trees, and armed with the rod of public authority, announces his coming by loud and difmal fcreams in the woods near the town. He begins the pantomime at the approach of night; and as foon as it is dark, he enters the town, and proceeds to the *Bentang* or market-place, at which all the inhabitants immediately affemble.

It may eafily be fuppofed that this exhibition is not much relifhed by the women; for as the perfon in difguife is entirely unknown to them, every married female fufpects that the vifit may poffibly be intended for herfelf; but they dare not refufe to appear when they are fummoned; and the ceremony commences with fongs and dances, which continue till midnight, about which time Mumbo fixes on the offender. This unfortunate victim being thereupon immediately feized, is ftripped naked, tied to a poft, and feverely fcourged with Mumbo's rod, amidft the fhouts and derifion of the whole affembly; and it is remakable, that the reft of the women are the loudeft in their exclamations on this occafion againft their unhappy fifter. Daylight puts an end to this indecent

indecent and unmanly revel. It is truly aftonifhing that the women fhould be deluded by fo clumfy an impofture, and that the men fhould fo faithfully keep their own fecret. That the women are deluded feems evident; for Mr Park affures us, that the drefs of Mumbo is fuffered to hang on a tree at the entrance of each town; which could hardly be the cafe, if the women were not perfuaded that it is the drefs of fome fupernatural being.

MUNSHY, a Perfian fecretary or writer.

MUNSUB, in the language of Bengal, a dignity or command conferred by the emperor.

MUNSUBDAR, a dignitary or commander.

MURRAY (William), afterwards Earl of Mansfield and Lord Chief Juftice of England, was the fourth fon of David Vifcount Stormont. He was born on the 2d day of March 1705 at Perth, in the kingdom of Scotland, of which kingdom his father was a peer. His refidence in Scotland, however, was of fhort duration; for he was carried up to London at the early age of three years. Hence his total exemption from the peculiarities of the dialect of his native country.

At the age of fourteen he was admitted as a king's fcholar of Weftminfter fchool; and during his refidence in that feminary, fays his contemporary Bifhop Newton, he gave early proofs of his uncommon abilities, not fo much in his poetry, as in his other exercifes; and particularly in his declamations, which were fure tokens and prognoftics of that eloquence which grew up to fuch a maturity and perfection at the bar, and in both houfes of parliament. At the election in May 1723, he ftood firft on the lift of thofe gentlemen who were fent to Oxford, and was entered of Chrift Church, June the 18th, in that year. In the year 1727 he had taken the degree of B. A. and on the death of King George the Firft, was amongft thofe of the univerfity who compofed verfes on that event.

In April 1724 he was admitted a ftudent of Lincoln's Inn, though he ftill continued to refide much in the univerfity; where, on the 26th of June 1730, he took the degree of M. A. and foon afterwards left Oxford, determined to make the tour of Europe before he fhould devote himfelf ferioufly to bufinefs. About this period he wrote two letters to a young nobleman on the ftudy of ancient and modern hiftory, which are publifhed by his biographer Mr Holliday, and fhew how amply his own mind was then ftored with general literature.

On his return to England he commenced his legal ftudies; but proceeded not in the way then ufually adopted, of labouring in the chambers of a fpecial pleader, or copying (to ufe the words of Blackftone) the trafh of an attorney's office. Being bleffed with the powers of oratory in their higheft perfection, and having foon an opportunity of difplaying them, he very early acquired the notice of the chancellor and the judges, as well as the confidence of the inferior practifers. How much he was regarded in the houfe of lords, Pope's well-known couplet will prove:

Grac'd as thou art with all the power of words,
So known, fo honour'd at the houfe of lords.

The graces of his elocution, however, produced their ufual effect with a certain clafs of people, who would not believe that fuch bright talents could affociate with the more folid attainments of the law, or that a man of genius and vivacity could be a profound lawyer. As Pope obferved at that time,

The Temple late two brother ferjeants faw,
Who deem'd each other oracles of law;
With equal talents thefe congenial fouls,
One lull'd the exchequer, and one ftunn'd the rolls;
Each had a gravity would make you fplit,
And fhook his head at Murray as a wit.

It is remarkable that this ridiculous prejudice accompanied Lord Mansfield to the end of his judicial life, in fpite of daily proofs exhibited in the court of King's Bench and in the Houfe of Lords, of very profound knowledge of the abftrufeft points of jurifprudence. Lord Chefterfield has given his fanction to this unfounded opinion. In a letter to his fon, dated Feb. 12. 1754, he fays, "The prefent Solicitor General Murray has lefs law than many lawyers, but he has more practice than any, merely upon account of his eloquence, of which he has a never-failing ftream."

In the outfet of Lord Mansfield's life, it will be the lefs furprifing, that a notion fhould have been entertained of his addicting himfelf to the purfuits of Belles Lettres too much, when the regard fhewn to him by Mr Pope, who defpotically ruled the regions of literature at that period, is confidered. That great Poet feemed to entertain a particular affection for our young lawyer, and was eager to fhew him marks of his regard. He addreffed to him his imitation of the 6th Epiftle of the Firft Book of Horace; and even condefcended to become his mafter in the art of elocution. "Mr Murray (fays his biographer) was one day furprifed by a gentleman of Lincoln's Inn, who could take the liberty of entering his rooms without the ceremonious introduction of a fervant, in the fingular act of practifing the graces of a fpeaker at a glafs, while Pope fat by in the character of a friendly preceptor. Mr Murray, on this occafion, paid that poet the handfome compliment of *Tu es mihi Mæcenas* (A)."

Whatever propenfities this fprightly lawyer might have towards polite literature, he did not permit them to divert his attention from his profeffion. He foon diftinguifhed himfelf in an extraordinary manner, as may be feen by thofe who are converfant with, or chufe to refer to the Books of Reports. In the year 1736, the murder of Captain Porteous by a mob in Edinburgh, after he had been reprieved, occafioned a cenfure to fall on that city, and a bill of pains and penalties was brought into parliament againft the Lord Provoft and the corporation; which, after various modifications, and a firm and unabated oppofition in every ftage of its progrefs, paffed into a law. In both Houfes Mr Murray was employed as an advocate, and fo much to the fatisfaction of his clients, that afterwards, in September 1743, he was prefented with the freedom of Edinburgh in a gold box, profeffedly, as it was declared,

(A) It is thus that eminence is attained even by genius, and Mr Murray was properly employed; though we do not clearly perceive the ufe of the glafs, when his mafter was watching all his geftures.

Murray. red, for his signal services by speeches to both Houses of Parliament in the conduct of that business.

On the 24th of November 1738, he had married Lady Elizabeth Finch, daughter of the Earl of Winchelsea, and in the month of November 1742, was appointed Solicitor General in the place of Sir John Strange who resigned (B). He likewise was chosen to represent the town of Boroughbridge in Parliament, for which place he was also returned in 1747 and 1754.

In the month of March 1746-7 he was appointed one of the managers for the impeachment of Lord Lovat by the House of Commons, and it fell to his lot to observe on the evidence previous to the Lords giving their judgment. This task he executed with so much candour, moderation, and gentleman-like propriety, that Lord Talbot, at the conclusion of his speech, paid him the following compliment: "The abilities of the learned manager who just now spoke, never appeared with greater splendour than at this very hour, when his candour and humanity has been joined to those great abilities which have already made him so conspicuous, that I hope one day to see him add lustre to the dignity of the first civil employment in this nation." Lord Lovat himself also bore testimony to the abilities of his adversary: "I thought myself (says his lordship) very much loaded by one Murray (c), who your lordships know was the bitterest evidence there was against me. I have since suffered by another Mr Murray, who, I must say with pleasure, is an honour to his country, and whose eloquence and learning is much beyond what is to be exprest by an ignorant man like me. I heard him with pleasure, though it was against me. I have the honour to be his relation, though perhaps he neither knows it nor values it. I wish that his being born in the North may not hinder him from the preferment that his merit and learning deserve."

During the time that Mr Murray continued in office, he supported, with great ability, the administration with which he was connected; and, of course, rendered himself obnoxious to those who were in opposition. Nothing, however, could be urged either against his public conduct or his private life; but he was involved in some trouble by an ill-devised tale, concurring with the known principles of the family of Stormont, to make him suspected of Jacobitism. Of this affair, a full and particular account is given by the late Lord Melcombe in the following words:

"Messrs Murray, Fawcett, and Stone, were much acquainted, if not school-fellows, in earlier life. Their fortune led them different ways; Fawcett's was to be a country lawyer and recorder of Newcastle. Johnson, now Bishop of Gloucester, was one of their associates. On the day the King's birth day was kept, they dined at the Dean of Durham's at Durham; this Fawcett, Lord Ravensworth, Major Davidson, and one or two more, who retired after dinner into another room. The conversation turning upon the late Bishop of Gloucester's preferments, it was asked who was to have his prebend of Durham? The Dean said, that the last news from London was, that Dr Johnson was to have it: Fawcett said, he was glad that Johnson got off so well, for he remembered him a Jacobite several years ago, and that he used to be with a relation of his who was very disaffected, one Vernon, a mercer, where the Pretender's health was frequently drunk. This passing among a few familiar acquaintance, was thought no more of at the time: it spread, however, so much in the North (how I never heard accounted for), and reached town in such manner, that Mr Pelham thought it necessary to desire Mr Vane, who was a friend to Fawcett, and who employed him in his business, to write to Fawcett, to know if he had said this of Johnson, and if he had, if it was true.

"This letter was written on the 9th of January; it came to Newcastle the Friday following. Fawcett was much surprised; but the post going out in a few hours after its arrival, he immediately acknowledged the letter by a long, but not very explicit, answer. This Friday happened to be the club-day of the neighbouring gentlemen at Newcastle. As soon as Lord Ravensworth, who was a patron and employer of Fawcett, came into the town, Fawcett acquainted him with the extraordinary letter he had received; he told him that he had already answered it; and being asked to shew the copy, said he kept none; but desired Lord Ravensworth to recollect if he held such a conversation at the Deanry of Durham the day appointed for the birth-day. Ravensworth recollected nothing at all of it: they went to the club together, and Ravensworth went the next moreing to see his mother in the neighbourhood, with whom he staid till Monday; but this thing of such consequence lying upon his thoughts, he returned by Newcastle. He and Fawcett had another conversation; and in endeavouring to refresh each other's memory about this dreadful delinquency of Johnson, Fawcett said he could not recollect positively at such a distance of time, whether Johnson drank these healths, or had been present at the drinking of them, but that Murray and Stone had done both several times. Ravensworth was excessively alarmed at this with relation to Stone, on account of his office about the prince; and thus the affair of Johnson was quite forgotten, and the episode became the principal part. There were many more conferences between Ravensworth and Faw- Murray.

(B) On this occasion a doggrel poem was published by one Morgan, a person then at the bar, entitled, "The Causidicade," in which all the principal lawyers were supposed to urge their respective claims to the post. At the conclusion it is said,

> Then Murray, prepar'd with a fine panegyric
> In praise of himself, would have spoke it like Garrick;
> But the President stopping him said, "As in truth
> "Your worth and your praise is in every one's mouth,
> "'Tis needless to urge what's notoriously known,
> "The office, by merit, is your's all must own;
> "The voice of the public approves of the thing,
> "Concurring with that of the Court and the King."

(c) One of the evidences against him.

Murray.

cett upon this subject, in which the latter always persisted that Stone and Murray were present at the drinking, and did drink those healths. It may be observed here, that when he was examined upon oath, he swore to the year 1731 or 1732, at latest. Fawcett comes up as usual about his law business, and is examined by Messrs Pelham and Vane, who never had heard of Murray or Stone being named: he is asked, and answers only with relation to Johnson, never mentioning either of the others; but the love of his country, his king, and posterity, burned so strongly in Ravensworth's bosom, that he could have no rest till he had discovered this enormity. Accordingly, when he came to town, he acquainted the ministry and almost all his great friends with it, and insisted upon the removal of Stone. The ministry would have slighted it as it deserved; but as he persisted, and had told so many of it, they could not help laying it before the king, who, though he himself slighted it, was advised to examine it; which examination produced the most injudicious proceeding in parliament *."

* Lord Melcombe's Diary, p. 220.

This is Lord Melcombe's account; and the same author informs us, that Mr Murray, when he heard of the committee being appointed to examine this idle affair, sent a message to the king, humbly to acquaint him, that if he should be called before such a tribunal on so scandalous and injurious an account, he would resign his office, and would refuse to answer. It came, however, before the House of Lords, 22d January 1753, on the motion of the Duke of Bedford.

The debate was long and heavy, says Lord Melcombe; the Duke of Bedford's performance moderate enough; he divided the House, but it was not told, for there went below the bar with him the Earl Harcourt, Lord Townshend, the Bishop of Worcester, and Lord Talbot only. The Bishop of Norwich and Lord Harcourt both spoke, not to much purpose; but neither of them in the least supported the Duke's question.

Upon the whole, Lord Melcombe concludes, "It was the worst judged, the worst executed, and the worst supported point that I ever saw of so much expectation."

The King, his late Majesty, viewed it in its true light; and is reported to have said, "Whatever they were when Westminster boys, they are now my very good friends." He was likewise, as we have been informed by a gentleman connected with the family of Stormont, so delighted with Mr Murray's speech in his own vindication, that he desired to have a copy of it, as a model of dignified and candid eloquence. Fawcett, the original author of the story, seems indeed to have been a very sneaking knave, totally unworthy of credit. Bishop Johnson, who was overlooked in the turmoil, excited by the supposed guilt of Murray and Stone (see Stone, in this *Suppl.*) went to Fawcett's chambers in the Temple, and desired an interview. Being told by the servant that his master was not at home, he renewed his visit very early next morning, and declared his resolution to wait till Mr Fawcett should rise, the laundress having inadvertently confessed that he was still in bed. Fawcett, upon this, left his thorny pillow with reluctance; for something sharper than thorns (says Mr Holliday) awaited him, which he could not now possibly avoid. The result of the interview produced expressions of deep contrition, together with a letter addressed to the Lord Bishop of Gloucester, acknowledging, in the most explicit terms, that his Lordship was innocent of the charge which he had been the instrument of bringing against him.

Murray.

On the advancement of Sir Dudley Ryder to the chief justiceship of the King's Bench in 1754, Mr Murray succeeded him as attorney general; and on his death, November 1756, again became his successor as chief justice, when he was created Baron of Mansfield, in the county of Nottingham, with remainder to the heirs male of his body lawfully begotten.

As soon as Lord Mansfield was established in the King's Bench, he began to make improvements in the practice of that court. On the 12th of November, four days after he had taken his seat, he made a very necessary regulation, observing, "Where we have no doubt, we ought not to put the parties to the delay and expence of a farther argument; nor leave other persons, who may be interested in the determination of a point so general, unnecessarily under the anxiety of suspence."

The anxiety of suspence, from this period, was no longer to be complained of in the court of King's Bench. The regularity, punctuality, and dispatch of the new chief justice, afforded such general satisfaction, that they, in process of time, drew into that court most of the causes which could be brought there for determination.

Sir James Burrows says, "I am informed, that at the sittings for London and Middlesex only, there are not so few as 800 causes set down in a year, and all disposed of. And though many of them, especially in London, are of considerable value, there are not more, upon an average, than between 20 and 30 ever heard of afterwards in the shape of special verdicts, special cases, motions for new trials, or in arrest of judgment. Of a bill of exceptions there has been no instance (I do not include judgments upon criminal prosecutions; they are necessary consequences of the convictions). My reports give but a very faint idea of the extent of the whole business which comes before the court: I only report what I think may be of use as a determination or illustration of some matter of law. I take no notice of the numerous questions of fact which are heard upon affidavits (the most tedious and irksome part of the whole business). I take no notice of a variety of contestations, which, after having been fully discussed, are decided without difficulty or doubt. I take no notice of many cases which turn upon a construction so peculiar and particular, as not to be likely to form a precedent for any other case. And yet, notwithstanding this immensity of business, it is notorious, that, in consequence of method, and a few rules which have been laid down to prevent delay (even where the parties themselves would willingly consent to it), nothing now hangs in court. Upon the last day of the very last term, if we exclude such motions of the term as by desire of the parties went over of course as peremptories, there was not a single matter of any kind that remained undetermined, excepting one case relating to the proprietary Lordship of Maryland, which was professedly postponed on account of the present situation of America. One might speak to the same effect concerning the last day of any former term for some years backward."

The same author also informs us that, excepting two cases, cafes, there had not been, from the 6th of November 1756 to the time of his then prefent publication, 26th May 1776, a final difference of opinion in the court in any cafe, or upon any point whatfoever. "It is remarkable, too (he adds), that, excepting thefe two cafes, no judgment given during the fame period has been reverfed, either in the exchequer chamber or in parliament; and even thefe reverfals were with great diverfity of opinion among the judges." Of the two cafes here mentioned, one was the famous queftion concerning literary property, which the majority of the judges of the court of King's Bench held to be permanent; and in fupport of which opinion, fuch arguments were urged by the chief juftice, as have not yet perhaps been completely anfwered.

The ill fuccefs of the war, which had lately been begun, occafioned a change in the adminiftration; and the conflicts of contending parties rendered it impracticable for the crown, at that juncture, to fettle a new miniftry. In order therefore to give paufe to the violence of both fides, Lord Mansfield was induced to accept the poft of chancellor of the exchequer on the 9th of April 1757; which he held until the 2d of July in the fame year. During this interval, he employed himfelf, with great fuccefs, to bring about a coalition; which being effected, produced a feries of events, which raifed the glory of Great Britain to the higheft point at which it has ever been feen. In the fame year he was offered, but refufed, the office of Lord High Chancellor; and in November 1758, he was elected a governor of the charter houfe, in the room of the Duke of Marlborough, then lately deceafed.

For feveral years after this period, the tenor of Lord Mansfield's life was marked only with a moft fedulous difcharge of the duties of his office. In 1760 Geo. II. died, and the new reign commenced with alterations in the adminiftration; which gave rife to a virulent fpirit of oppofition, conducted with a degree of violence and afperity never known at any former time. As a friend to the then adminiftration, Lord Mansfield was marked out for a more than ordinary fhare of malicious invective. It is in allufion to this, that Warburton, after tracing the rife and progrefs of the irreligion and licentioufnefs which then prevailed, and obferving that, amid fuch general corruption, the pure adminiftration of public juftice ftill afforded a cheerful confolation to thinking men, proceeds thus:

"But the evil genius of England would not fuffer us to enjoy it long; for, as if envious of this laft fupport of government, he hath now inftigated his blackeft agents to every extent of their malignity; who, after the moft villanous infults on all other orders and ranks in fociety, have at length proceeded to calumniate even the king's fupreme court of juftice, under its ableft and moft unblemifhed adminiftration. After this, who will not be tempted to defpair of his country, and fay with the good old man in the fcene,

——" *Ipfa fi cupiat falus*
" *Servare, prorfus non poteft, hanc Familiam* (D)?"

A change of adminiftration again took place in 1765, which introduced the Marquis of Rockingham and his friends to govern the country; and the meafures then adopted not agreeing with Lord Mansfield's fentiments, he, for the firft time, became an opponent of government. On the bill for repealing the ftamp act, he fpoke, and divided againft it; and is fuppofed to have had fome fhare in the compofition of the protefts on that occafion, though he did not fign them. In the fame year, he is faid to have animadverted, with no fmall degree of feverity, on the incautious expreffions of Lord Camden, on the affair of prohibiting the exportation of corn, that it was but a 40 days tyranny at the outfide. (E).

In 1767 the Diffenters caufe was determined, in which Lord Mansfield delivered a fpeech, which has fince been printed, and fhews his Lordfhip to have been a fteady friend to religious toleration, as well as to the rights of the eftablifhed church. The confcientious Diffenters themfelves lavifhed upon that fpeech the higheft praife; whilft others of them, in the fucceeding year, deluged the public prints with torrents of abufe on the Chief Juftice. In that year was the general election. Mr Wilkes returned from abroad, became a candidate for the city of London, and afterwards was chofen reprefentative for the county of Middlefex. Having been outlawed fome years before, he now applied for a reverfal of that proceeding. On the 8th of June, the confideration of it came before the court of King's Bench; when the judges delivered their opinions very fully, and were unanimous that the outlawry was illegal, and muft be reverfed. On this occafion Lord Mansfield took the opportunity of entering into a full ftatement of the cafe, and a juftification of his own conduct. The reader will find the cafe reported by Sir James Burrow; from whom we fhall extract the following, which appears to have been the moft important part of his Lordfhip's fpeech.

" It is fit to take fome notice of the various terrors hung out; the numerous crowds which have attended, and now attend, in and about the hall, out of all reach of hearing what paffes in court; and the tumults which in other places have fhamefully infulted all order and government. Audacious addreffes in print dictate to us, from thofe they call the people, the judgment to be given now, and afterwards upon the conviction. Reafons of policy are urged, from danger to the kingdom, by commotions and general confufion.

" Give me leave to take the opportunity of this great and refpectable audience, to let the whole world know all fuch attempts are vain. Unlefs we have been able to find an error which will bear us out to reverfe the outlawry, it muft be affirmed. The conftitution does not allow reafons of ftate to influence our judgment: God

(D) See the dedication of the 5th edition of the Divine Legation of Mofes, which deferves to be read at prefent with peculiar attention, as the work of a man of gigantic talents, deeply read in law as well as in theology.

(E) The fpeeches in the debate were never printed; but the fubftance of them all was confolidated in a pamphlet publifhed at the time, intitled, " A Speech againft the fufpending and difpenfing prerogative," 8vo. Since reprinted in Debrett's Debates, Vol. IV. p. 384.

God forbid it should! We must not regard political consequences, how formidable soever they may be; we are bound to say, *Fiat Justitia, ruat Cœlum.* The constitution trusts the king with reasons of state and policy: He may pardon offences; it is his to judge whether the law or the criminal should yield. We have no election. None of us encouraged or approved the commission of either of the crimes of which the defender is convicted: none of us had any hand in his being prosecuted. As to myself, I took no part (in another place) in the addresses for that prosecution. We did not advise or assist the defender to fly from justice; it was his own act, and he must take the consequences. None of us have been consulted, or had any thing to do with the present prosecution. It is not in our power to stop it; it was not in our power to bring it on. We cannot pardon. We are to say what we take the law to be. If we do not speak our real opinions, we prevaricate with God and our own consciences.

"I pass over many anonymous letters I have received: those in print are public; and some of them have been brought judicially before the court. Whoever the writers are, they take the wrong way. I will do my duty unawed. What am I to fear? That *mendax infamia* from the press, which daily coins false facts and false motives? The lies of calumny carry no terror to me. I trust that my temper of mind, and the colour and conduct of my life, have given me a suit of armour against these errors If, during this king's reign, I have ever supported his government, and assisted his measures, I have done it without any other reward than the consciousness of doing what I thought right. If I have ever opposed, I have done it upon the points themselves, without any collateral views.' I honour the king, and respect the people. But many things acquired by the favour of either are, in my account, objects not worth ambition. I wish popularity; but it is that popularity which follows, not that which is run after.— It is that popularity which, sooner or later, never fails to do justice to the pursuit of noble ends by noble means. I will not do that which my conscience tells me is wrong upon this occasion, to gain the huzzas of thousands, or the daily praise of all the papers which come from the press. I will not avoid doing what I think is right, though it should draw on me the whole artillery of libels, all that falsehood and malice can invent, or the credulity of a deluded populace can swallow. I can say with a great magistrate, upon an occasion, and under circumstances not unlike, '*Ego hoc animo semper fui, ut invidiam virtute partam, gloriam, non invidiam putarem.*'

"The threats go furthur than abuse: Personal violence is denounced. I do not believe it: it is not the genius of the worst men of this country in the worst of times. But I have set my mind at rest. The last end that can happen to any man never comes too soon, if he falls in support of the law and liberty of his country (for liberty is synonymous to law and government). Such a shock, too, must be productive of public good: It might awake the better part of the kingdom out of that lethargy which seems to have benumbed them; and bring the mad part back to their senses, as men intoxicated are sometimes stunned into sobriety.

"Once for all, let it be understood, that no endeavours of this kind will influence any man who at present sits here. If they had any effect, it would be contrary to their intent: Leaning against their impression might give a bias the other way. But I hope, and I know, that I have fortitude enough to resist even that weakness. No libels, no threats, nothing that has happened, nothing that can happen, will weigh a feather against allowing the defendant, upon this and every other question, not only the whole advantage he is intitled to from substantial law and justice, but every benefit from the most critical nicety of form, which any other defender could claim under the like objection. The only effect I feel is an anxiety to be able to explain the grounds upon which we proceed; so as to satisfy all mankind, that a flaw of form given way to in this case, could not have been got over in any other."

In January 1770, Lord Mansfield again was offered the Great Seal, which was given to Mr Charles York: and in Hilary Term 1771, he a third time declined the same offer, and the Seal was entrusted to Lord Bathurst.

The year 1770 was also memorable for various attacks made on his Lordship's judicial character, in both the Houses of Lords and Commons. In one of these, the propriety of a direction given to the jury in the case of the king and Woodfal was called in question; which occasioned his Lordship to produce to the House a copy of the unanimous opinion of the court of King's Bench in that cause; which, after being much canvassed and opposed, was suffered to stand its ground without being over-ruled.

On the 19th of October 1776, his Lordship was advanced to the dignity of an Earl of Great Britain, by the title of the Earl of Mansfield, and to his male issue; and for want of such issue, to Louisa Viscountess Stormont, and to her heirs-male by David Viscount Stormont her husband. The same title, in 1792, was limited to Lord Stormont himself; who afterwards succeeded to it.

We come now to a period of his Lordship's life, which furnishes an event disgraceful to the age and country in which the fact was committed. An union of folly, enthusiasm, and knavery, had excited alarms in the minds of some weak people, that encouragements were given to the favourers and professors of the Roman Catholic faith inconsistent with religion and true policy. The act of Parliament, which excited the clamour, had passed with little opposition, and had not received any extraordinary support from Lord Mansfield. The minds of the public were inflamed by artful misrepresentations; the rage of a popular mob was soon directed towards the most eminent persons. Accordingly, in the night between Tuesday the 6th and Wednesday the 7th of June 1780, his Lordship's house in Bloomsbury Square was attacked by a party of rioters, who, on the Friday and Tuesday preceding, had, to the amount of many thousands, surrounded the avenues of both Houses of Parliament, under pretence of attending Lord George Gordon when he presented the petition from the Protestant Association. On Tuesday evening the prison of Newgate had been thrown open, all the combustible part reduced to ashes, and the felons let loose upon the public. It was after this attempt to destroy the means of securing the victims of criminal justice that the rioters assaulted the residence of the chief magistrate of the first criminal court in the kingdom; nor were they dispersed till they had burnt all the furniture, pictures, books, manuscripts, deeds, and, in short, every thing which fire could consume in his Lordship's

Murray. ſhip's houſe; ſo that nothing remained but the walls, which were ſeen next morning almoſt red-hot from the violence of the flames, preſenting a melancholy and awful ruin to the eyes of the paſſengers. For a fuller account of thoſe dreadful riots, ſee BRITAIN, n° 644. *Encyclopædia.*

So unexpected was this daring outrage on order and government, that it burſt on Lord Mansfield without his being prepared in the ſlighteſt manner to reſiſt it. He eſcaped with his life only, and retired to a place of ſafety, where he remained until the 14th of June, the laſt day of term, when he again took his ſeat in the court of King's Bench. "The reverential ſilence (ſays Mr Douglas) which was obſerved when his Lordſhip reſumed his place on the Bench, was expreſſive of ſentiments of condolence and reſpect, more affecting than the moſt eloquent addreſs the occaſion could have ſuggeſted.

"The amount of that part of Lord Mansfield's loſs which might have been eſtimated, and was capable of a compenſation in money, is known to have been very great. This he had a right to recover againſt the *hundred.* Many others had taken that courſe; but his Lordſhip thought it more conſiſtent with the dignity of his character not to reſort to the indemnification provided by the legiſlature. His ſentiments, on the ſubject of a reparation from the ſtate, were communicated to the Board of Works in a letter, dated 18th July 1780, written in conſequence of an application which they had made to him (as one of the principal ſufferers), purſuant to directions from the treaſury, founded on a vote of the Houſe of Commons, requeſting him to ſtate the nature and amount of his loſs. In that letter, after ſome introductory expreſſions of civility to the ſurveyor general, to whom it was addreſſed, his Lordſhip ſays, 'Beſides what is irreparable, my pecuniary loſs is great. I apprehended no danger, and therefore took no precaution. But how great ſoever that loſs may be, I think it does not become me to claim or expect reparation from the ſtate. I have made up my mind to my misfortune, as I ought, with this conſolation, that it came from thoſe whoſe object manifeſtly was general confuſion and deſtruction at home, in addition to a dangerous and complicated war abroad. If I ſhould lay before you any account or computation of the pecuniary damage I have ſuſtained, it might ſeem a claim or expectation of being indemnified. Therefore you will have no further trouble upon this from, &c.—*Mansfield.*'"

From this time the luſtre of Lord Mansfield continued to ſhine with unclouded brightneſs until the end of his political life, unleſs his oppoſition to the meaſures of the preſent adminiſtration, at the early period of their appointment, ſhall be thought to detract, in ſome ſmall degree, from his merit. It is certain many of his admirers ſaw, with concern, a connection with the opponents of government at that juncture, ſcarce compatible with the dignity of the chief juſtice of Great Britain. At length infirmities preſſed upon him, and he became unable to attend his duty with the ſame punctuality and aſſiduity with which he had been accuſtomed. It has been ſuppoſed that he held his office after he was diſabled from executing the duties of it, from a wiſh to ſecure the ſucceſſion of it to a very particular friend. Be this as it may, the chief juſtice continued in his office until the month of June 1788, when he ſent in his reſignation.

1800.

From this period the bodily powers of his Lordſhip continued to decline; his mental faculties, however, remained without decay almoſt to the laſt. During this time he was particularly inquiſitive and anxious about the proceedings in France, and felt his ſenſibility, in common with every good man, wounded by the horrible inſtance of democratic infatuation in the murder of the innocent Louis XVI. He lived juſt long enough to expreſs his ſatisfaction at the check given to the French by the Prince of Cobourg in March 1793; on the 20th of which month, after continuing ſome days in a ſtate of inſenſibility, he departed this life, at the age of 88 years.

"In his political oratory (ſays a writer of the preſent times), he was not without a rival; no one had the honour of *ſurpaſſing* him; and let it be remembered, that his competitor was PITT.

"The rhetorician that addreſſed himſelf to Tully in theſe memorable words—*Demoſthenes tibi præripuit ne primus eſſes Orator, tu illi ne ſolus*—anticipated their application to Mansfield and Pitt. If the one poſſeſſed Demoſthenean fire and energy, the other was at leaſt a Cicero. Their oratory differed in ſpecies, but was equal in merit. There was, at leaſt, no ſuperiority on the ſide of Pitt. Mansfield's eloquence was not, indeed, of that daring, bold, declamatory kind, ſo irreſiſtibly powerful in the momentary huſtle of popular aſſemblies; but it was poſſeſſed of that pure and Attic ſpirit, and ſeductive power of perſuaſion, that delights, inſtructs, and eventually triumphs. It has been very beautifully and juſtly compared to a river, that meanders through verdant meads and flowery gardens, reflecting in its cryſtal boſom the varied objects that adorn its banks, and refreſhing the country through which it flows.

"To illuſtrate his oratory by example, would require voluminous tranſcripts from the records of Parliament; and it is unneceſſary, as we can appeal to living recollection.

"Having added weight and dignity to the offices of attorney and ſolicitor general, his reputation as a ſpeaker, a lawyer, and a politician, elevated him to the peerage, and the exalted poſt of chief juſtice of England. He aſcended to the dignities of ſtate by rapid ſtrides: they were not beſtowed by the caprice of party favour or affection. They were (as was ſaid of Pliny) liberal diſpenſations of power upon an object that knew how to add new luſtre to that power, by the rational exertion of his own.

"Here we can ſpeak of this great man within our own recollection; and however party prejudices may adopt their different favourites, and each contend in detracting from the merit of the other, it is, we believe, generally underſtood that precedence is allowed the Earl of Mansfield, as the firſt magiſtrate that ever ſo pre-eminently graced that important ſtation. The wiſdom of his deciſions, and unbiaſſed tenor of his public conduct, will be held in veneration by the ſages of the law, as long as the ſpirit of the conſtitution, and juſt notions of equity, continue to have exiſtence. No man has ever, in an equal degree, poſſeſſed that wonderful ſagacity in diſcovering chicanery and artifice, and ſeparating fallacy from truth, and ſophiſtry from argument, ſo as to hit the exact equity of the caſe. He ſuffered not juſtice to be ſtrangled in the nets of form.

"His memory was aſtoniſhing—he never took notes, or, Murray. or, if he did, feldom or ever confulted them." His references to expreffions which fell from him in the courfe of the debate, or his quotations from books, were fo faithful that they might have been faid to have been repeated *verbatim*. The purpofes to which he employed thefe amazing talents were ftill more extraordinary: if it was the weak part of his opponent's arguments that he referred to, he was fure to expofe its fallacy, weaknefs, or abfurdity, in the moft poignant fatire, or hold it up in the moft ridiculous point of view. If, on the contrary, it were a point on which his adverfaries laid their chief ftrefs, he ftated the words correctly; collected their obvious meaning, confidered the force of the feveral arguments that had or might have been raifed upon them, with a precifion that would induce an auditor almoft to fuppofe that he had previoufly confidered the whole, and that his fpeech was the refult of much previous ftudy.

"It may be faid of Mansfield as of Virgil, that if he had any faults, they might be confidered in the fame manner with thofe of fome eminent fixed ftar, which, if they exift at all, are above the reach of human obfervation. The luminous æther of his life was not obfcured by any fhade dark enough to be denominated a defect. On account of his defcent, local prejudices and propenfities were imputed to him, and his conduct, on that account, examined with a microfcopic eye; but the optic through which it is viewed poffeffed a party tinge, equally odious and deceptive.

"His political principles were ever confiftent; and to preferve confiftency in fuch ftations and in fuch times as occupied the life of Mansfield, conftitutes an ordeal ftrongly impreffive of virtue. It has been faid that he wanted fpirit. Is the uniform oppofition of popular opinion, and apparently the contempt of it, any proof of the affertion? His fpeech and conduct in the affair of Wilkes's outlawry, when popular prejudice ran in torrents, illuftrate each other. He defpifed (to borrow an expreffion of his own) that mufhroom popularity that is raifed without merit, and loft without a crime. He difdained being the flave of popular impulfe, or to acknowledge the fhouts of a mob for the trumpet of fame."

He had a mind too great to be afhamed of revering the ordinances of religion; and as, after the moft impartial inquiry, he was a firm believer of the truth and importance of Chriftianity, he frequented the church regularly, and received the holy facrament on the higher feftivals. Mr Holliday has publifhed a fermon, which he fays was dictated by Lord Mansfield to his friend bifhop Johnfon, and preached by that prelate before the Houfe of Lords. It is a very ferious and appropriate difcourfe; but judging upon internal evidence, we fhould not have fuppofed it the compofition of the eloquent and argumentative chief juftice of England. His Lordfhip's will, which was written with his own band, upon little more than half a fheet of paper, begins with the following elegant and pious paragraph, with which we fhall conclude this fketch of his character:

"When it fhall pleafe Almighty God to call me to that ftate, to which, of all I now enjoy, I can carry only the fatisfaction of my own confcience, and a full reliance upon his mercy through Jefus Chrift, I defire that my body may be interred as privately as may be; and out of refpect for the place of my early education, I fhould wifh it to be in Weftminfter Abbey." It was interred in Weftminfter Abbey, in the fame vault with the Countefs (who had died April 10, 1784, between the late Earl of Chatham and Lord Robert Manners.

Mufeum. MUSEUM, in the language of the prefent day, is a building in which are depofited fpecimens of every object that is in any degree curious, whether fuch objects be natural or artificial. What the word *mufeum* expreffed originally, has been told under that title in the *Encyclopædia*.

A complete mufeum contains collections of preferved beafts, birds, fifhes, reptiles, &c.; models of machines; rare manufcripts; and indeed fpecimens of every thing neceffary to illuftrate phyfical fcience, to improve art, to aid the antiquarian in his refearches, and to exhibit the manners and cuftoms of men in diftant ages and nations. As natural objects of uncommon fize or beauty, and other rare productions, were, in the earlieft periods, confecrated to the gods, the temples were, of courfe, the firft repofitories of fuch collections, or, in other words, the firft *Mufeums*. This, we think, has been completely proved by Profeffor Beckmann *. *Inventions vol. ii. p. 44.

"When Hanno (fays he) returned from his diftant voyages, he brought with him to Carthage two fkins of the hairy women whom he found on the Gorgades iflands, and depofited them as a memorial in the temple of Juno, where they continued till the deftruction of the city. The horns of a Scythian animal, in which the Stygian water that deftroyed every other veffel could be contained, were fent by Alexander as a curiofity to the temple of Delphi, where they were fufpended with an infcription, which has been preferved by Ælian. The monftrous horns of the wild bulls which had occafioned fo much devaftation in Macedonia, were, by order of King Philip, hung up in the temple of Hercules. The unnaturally formed fhoulder bones of Pelops were depofited in the temple of Elis. The horns of the fo called Indian ants were fhewn in the temple of Hercules at Erythræ; and the crocodile found in attempting to difcover the fources of the Nile was preferved in the temple of Ifis at Cæfarea. A large piece of the root of the cinnamon tree was kept in a golden veffel in one of the temples at Rome, where it was examined by Pliny. The fkin of that monfter which the Roman army in Africa attacked and deftroyed, and which probably was a crocodile, an animal common in that country, but never feen by the Romans before the Punic war, was, by Regulus, fent to Rome, and hung up in one of the temples, where it remained till the time of the Numantine war (A). In the temple of Juno, in the ifland of Melita, there were a pair of elephants teeth of extraordinary fize, which were carried away by Mafiniffa's admiral, and tranfmitted to that prince, who, though he fet a high value upon them, fent them again back, becaufe he heard they had been taken from a temple. The head of a bafilifk was exhibited in one of the temples of Diana; and the bones of that fea monfter, probably a whale, to which Andromeda was expofed, were preferved at Joppa, and afterwards brought to Rome.

(A) We think, with the tranflator of Beckmann's Hiftory, that this animal was not the crocodile, but the *Boa conftrictor*. See Boa and Serpent, *Encycl.*

Rome. In the time of Paufanias, the head of the celebrated Calydonian boar was fhewn in one of the temples of Greece ; but it was then deftitute of briftles, and had fuffered confiderably by the hand of time. The monftrous tufks of this animal were brought to Rome, after the defeat of Anthony, by the Emperor Auguftus, who caufed them to be fufpended in the temple of Bacchus. Appollonius tells us, that he faw in India fome of thofe nuts which in Greece were preferved in the temples as curiofities."

Though thefe curiofities were preferved in the temples for purpofes very different from thofe for which our collections are made, there can be no doubt but that they contributed to promote the knowledge of natural hiftory. If it be true, as Pliny and Strabo inform us, that Hippocrates availed himfelf of the accounts which were hung up in the temple of Æfculapius of different difeafes, and of the medicines and mode of treatment by which they were cured ; it will eafily be believed, that the natural hiftorians availed themfelves, in a fimilar manner, of the various rare objects which were preferved in the temples of the other gods. This, we fee, Pliny actually did.

Suetonius informs us, that Auguftus had, in his palace, a collection of natural curiofities; and it is well known that Alexander gave orders to all huntfmen, bird-catchers, fifhermen, and others, to fend to Ariftotle whatever rare animals they could procure. M. Beckmann feems to be of opinion, that the firft private mufeum was formed by Apuleius, who, next to Ariftotle and his fcholar Theophraftus, certainly examined natural objects with the greateft ardour and judgment ; who caufed animals of every kind, and particularly fifh, to be brought to him either dead or alive, in order to defcribe their external and internal parts, their number and fituation, and to determine their characterifing marks, and eftablifh their real names ; who undertook diftant journeys to become acquainted with the fecrets of nature ; and who, on the Getulian mountains, collected petrefactions, which he confidered as the effects of Deucalion's flood.

The principal caufe why collections of natural curiofities were fcarce in ancient times, muft have been the ignorance of naturalifts in regard to the proper means of preferving fuch bodies as foon fpoil or corrupt. Some methods were indeed known and practifed, but they were all defective and inferior to that by fpirit of wine, which prevents putrefaction, and which, by its perfect tranfparency, permits the objects which are covered by it to be at all times viewed and examined. Thefe methods were the fame as thofe employed to preferve provifions, or the bodies of great men deceafed. They were put into falt brine or honey, or were covered over with wax. Thus the hippopotamus, defcribed by Columna, was fent to him from Egypt preferved in falt. The body of Agefipolis King of Sparta, who died in Macedonia, was fent home in honey ; the celebrated purple dye of the ancients was preferved frefh for many years by the fame means ; and at this day, when the Orientals are defirous of tranfporting fifh to any diftance, they cover them over with wax.

In thofe centuries which are ufually called the middle ages, the Profeffor finds no traces of what can be called a mufeum, except in the treafuries of emperors, kings, and princes, where, befides articles of great value, curiofities of art, antiquities, and relics, one fometimes found fcarce and fingular foreign animals, which were dried and preferved. Such objects were to be feen in the old treafury at Vienna ; and in that of S. Denis was exhibited the claw of a griffin, fent by a king of Perfia to Charlemagne ; the teeth of the hippopotamus, and other things of the like kind. In thefe collections, the number of the rarities always increafed in proportion as a tafte for natural hiftory became more prevalent, and as the extenfion of commerce afforded better opportunities for procuring the productions of remote countries. Menageries were eftablifhed to add to the magnificence of courts, and the ftuffed fkins of rare animals were hung up as memorials of their having exifted. Public libraries alfo were made receptacles for fuch natural curiofities as were from time to time prefented to them ; and as in univerfities the faculty of medicine had a hall appropriated for the diffection of human bodies, curiofities from the animal kingdom were collected there alfo by degrees ; and it is probable that the profeffors of anatomy firft made attempts to preferve different parts of animals in fpirit of wine, as they were obliged to keep them by them for the ufe of their fcholars; and becaufe in old times dead bodies were not given up to them as at prefent, and were more difficult to be obtained. Private collections appear for the firft time in the 16th century ; and there is no doubt (fays our author) that they were formed by every learned man who at that period applied to the ftudy of natural hiftory.

MUSHROOM, a fungous, of which fome of the principal fpecies have been defcribed in the *Encyclopædia* under the generic name Agericus. There is, however, one fpecies not mentioned there—the *Boletus hirfutus* of Bulliard, which is certainly worthy of notice, fince one of the French Chemifts has lately extracted from it a bright, fhining, and very durable yellow dye. This pretty large mufhroom grows commonly on walnut and apple-trees. Its colouring-matter is contained in abundance, not only in the tubular part, but alfo in the parenchyma of the body of the mufhroom. In order to extract it, the mufhroom is pounded in a mortar, and the liquor thence obtained is boiled for a quarter of an hour in water. An ounce of liquor is fufficient to communicate colouring-matter to fix pounds of water. When the liquor has been ftrained, the ftuff to be dyed is put into it, and boiled for a quarter of an hour. All kinds of ftuff receive this colour and retain it ; but on linen and cotton it is lefs bright. This colour may be modified, in a very agreeable manner, by the effect of mordants.

The procefs fucceeded beft on filk. When this fubftance, after being dyed, is made to pafs through a bath of foft foap, it acquires a fhining golden-yellow colour, which has a perfect refemblance to the yellow of that filk employed to imitate embroidery in gold, and which has hitherto been brought from China and fold at a dear rate, as the method of dyeing it is unknown in Europe. The yellow colour extracted from this mufhroom may be employed alfo with advantage for painting in water colours as well as in oil.

MUTSUDDIES, in Bengal, writers, accountants, officers of government.

MUZCOORET, allowances to zemindars in land or money. See Zemindar, *Suppl.*

N.

Nabob ‖ Nancowry.

NABOB, or Nowab, a title of courtefy given in India to Mahomedans high in ftation, particularly provincial governors.

The Sun's NADIR, is the axis of the cone projected by the fhadow of the earth: fo called, becaufe that axis being prolonged, gives a point in the ecliptic diametrically oppofite to the fun.

NAIB, a deputy.

NAKED, in architecture, as the naked of a wall, &c. is the furface, or plane, from whence the projectures arife; or which ferves as a ground to the projectures.

NANCOWRY, or Soury, as it is fometimes called, is one of the Nicobar ifles, and fituated nearly in the centre of the clufter (See Nicobar, *Encycl.*). Its length may be about eight miles, and its breadth nearly equal. The ifland of Comerty, which is near it, is more extenfive, but does not perhaps contain more folid land, being excavated by a very large bay from the fea. The fpace between thefe two iflands forms a capacious and excellent harbour, the eaftern entrance of which is fheltered by another ifland, called Tricut, lying at the diftance of about a league. The inlet from the weft is narrow, but fufficiently deep to admit the largeft fhips when the wind is fair.

The Danes have long maintained a fmall fettlement at this place, which ftands on the northern-moft point of Nancowry, within the harbour. A ferjeant and three or four foldiers, a few black flaves, and two rufty old pieces of ordnance, compofe the whole of their eftablifhment. They have here two houfes; one of which, built entirely of wood, is their habitation; the other, formerly inhabited by their miffionaries, ferves now for a ftorehoufe.

Thefe iflands are in general woody, but contain likewife fome portions of clear land. From the fummits of their hills the profpects are often beautiful and romantic. The foil is rich, and probably capable of producing all the various fruits and vegetables common to hot climates. The natural productions of this kind, which moftly abound, are cocoa nuts, *papias*, plantains, limes, tamarinds, beetle-nuts, and the *melôri*, a fpecies of breadfruit; yams, and other roots are cultivated and thrive; but rice is here unknown. The *mangoftain* tree, whofe fruit is fo juftly extolled, grows wild; and pine-apples of a delicious flavour are found in the woods.

Of all the Nicobar ifles Nancowry and Comerty are faid to be the beft peopled; the population of both being fuppofed to amount to eight hundred. The natives of Nancowry and of the Nicobar iflands in general, live in villages on the fea-fhore, and never erect their habitations inland (a). Their houfes are of a circular form, and are covered with elliptical domes, thatched with grafs and the leaves of cocoa nut. They are raifed up-on piles to the height of fix or eight feet above the ground; the floor and fides are laid with planks, and the afcent is by a ladder. In thofe bays or inlets which are fheltered from the furf, they erect them fometimes fo near the margin of the water as to admit the tide to flow under, and wafh away the ordure from below.

Nancowry.

In front of their villages, and a little advanced in the water, they plant beacons of a great height, which they adorn with tufts made of grafs, or the bark of fome tree. Thefe objects are difcernible at a great diftance, and are intended probably for landmarks; their houfes, which are overfhadowed by thick groves of cocoa-nut trees, feldom being vifible from afar.

The Nicobareans, though indolent, are in general robuft and well-limbed. Their features are fomewhat like the Malays, and their colour is nearly fimilar. The women are much inferior in ftature to the men, but more active in all domeftic affairs. Contrary to the cuftom of other nations, the women fhave the hair of their heads, or keep it clofe cropt, which gives them an uncouth appearance, in the eyes of ftrangers at leaft.

The inhabitants of Nancowry perform, every year, a very extraordinary ceremony in honour of the dead. It is thus defcribed by Lieutenant Colebrooke:

" On the anniverfary of this feftival, if it can be fo called, their houfes are decorated with garlands of flowers, fruits, and branches of trees. The people of each village affemble, dreft in their beft attire, at the principal houfe in the place, where they fpend the day in a convivial manner; the men, fitting apart from the women, fmoke tobacco, and intoxicate themfelves; while the latter are nurfing their children, and employed in preparations for the mournful bufinefs of the night. At a certain hour of the afternoon, announced by ftriking the *Goung*, the women fet up the moft difmal howls and lamentations, which they continue without intermiffion till about fun-fet; when the whole party get up, and walk in proceffion to the burying-ground. Arrived at the place, they form a circle around one of the graves, when a ftake, planted exactly over the head of the corpfe, is pulled up. The woman who is neareft of kin to the deceafed, fteps out from the crowd, digs up the fkull, and draws it up with her hands. At fight of the bones, her ftrength feems to fail her; fhe fhrieks, fhe fobs; and tears of anguifh abundantly fall on the mouldering object of her pious care. She clears it from the earth, fcrapes off the feltering flefh, and laves it plentifully with the milk of frefh cocoa-nuts, fupplied by the byftanders; after which fhe rubs it over with an infufion of faffron, and wraps it carefully in a piece of new cloth. It is then depofited again in the earth, and covered up; the ftake is replanted, and hung with the various trappings and imple-

(a) The great Nicobar iflands is perhaps an exception, where, it is faid, a race of men exifts, who are totally different in their colour and manners. They are connfidered as the *Aborigines* of the country. They live in the interior parts among the mountains, and commit frequent depredations on the peaceable inhabitants of the coafts.

implements belonging to the deceafed. They proceed then to the other graves; and the whole night is fpent in repetitions of thefe difmal and difguftful rites.

"On the morning following, the ceremony is concluded by an offering of many fat fwine; when the facrifice made to the dead affords an ample feaft to the living: they befmear themfelves with the blood of the flaughtered hogs, and fome, more voracious than others, eat the flefh raw. They have various ways, however, of dreffing their meat, but always eat it without falt. A kind of pafte made of the *melori* ferves them for bread; and they finifh their repaft with copious potations of *taury*, an inebriating liquor."

The Nicobareans are hofpitable and honeft, and are remarkable for a ftrict obfervance of truth, and for punctuality in adhering to their engagements. Such crimes as theft, robbery, and murder, are unknown in thefe iflands; but they do not want fpirit to revenge their injuries, and will fight refolutely; and flay their enemies, if attacked or unjuftly dealt with. Their only vice, if this failing can be fo called, is inebriation; but in their cups they are generally jovial and good-humoured. It fometimes, however, happens at their feafts, that the men of different villages fall out; and the quarrel immediately becomes general. In thefe cafes they terminate their differences in a pitched battle; where the only weapons ufed are long fticks, of a hard and knotty wood. With thefe they drub one another moft heartily, till, no longer able to endure the conflict, they mutually put a ftop to the combat, and all get drunk again.

NANKAR, ancient allowance to zemindars in land or money.

NANKEEN, or NAN-KING, is a well-known cotton ftuff, which derives its name from the ancient capital of China (See NAN-KING, *Encycl.*). It is, however, according to Van Braam, manufactured at a great diftance from that city, in the diftrict of *Fong-kiang-fou*, fituated in the fouth-eaft of the province of *Kiang-nam* upon the fea-fhore. The colour of nankeen is natural, the down of which it is made being of the fame yellow tinge with the cloth. The colour, as well as fuperior quality of this cotton, feems to be derived from the foil; for it is faid that the feeds of the nankeen cotton degenerate in both particulars when tranfplanted to another province, however little different in its climate. The common opinion, that the colour of the ftuff is given by a dye, occafioned an order from Europe, fome years ago, to dye the pieces of nankeen of a deeper colour than they had at that period; and the reafon of their being then paler than formerly is as follows:

Shortly after the Americans began to trade with China, the demand increafed to nearly double the quantity it was poffible to furnifh. To fupply this deficiency, the manufacturers mixed common white cotton with the brown; this gave it a pale caft, which was immediately remarked; and for this lighter kind no purchafer could be found, till the other was exhaufted. As the confumption is grown lefs for thefe fome years paft, the mixture of cotton is no longer neceffary, and nankeen is become what it was before. By keeping them two or three years, it even appears that they have the property of growing darker. This kind of ftuff muft be acknowledged to be the ftrongeft yet known. Many perfons have found that clothes made of it will laft three or four years, although for ever in the wafh. This it is that makes them the favourite wear for breeches and waiftcoats both in Europe and America. The white nankeen is of the fame quality, and is made of white cotton as good as the brown, and which alfo grows in Kiang-nam.

NAPLES-YELLOW, called alfo *Neapolitan earth*, in Italian *Giallolino*, and in French *Jaune de Naples*, is a beautiful pigment, concerning which we have much information from the indefatigable Beckmann. "It has (fays he) the appearance of an earth, is of a pale orange-yellow colour, ponderous, granulated, exceedingly friable, does not effloresce, nor become moift when expofed to the air, but when applied to the tongue feems to adhere to it. When reduced to a fine powder, it remains for fome time fufpended in water, but foon depofits itfelf at the bottom in the form of a flime. When boiled with water, the water, at leaft fometimes, is obferved to have a fomewhat faline tafte. It does not effervefce with acids, but is in part diffolved by aqua regia (nitro-muriatic acid). In the fire it emits no fulphureous vapour, is difficult to be fufed, and by that operation undergoes no material change, only that its colour becomes fomewhat redder. When fufed with colourlefs glafs, it gives it a milk-white colour, a fure proof that it contains no iron; and, with inflammable fubftances, there is obtained from it a regulus which has the appearance of a mixture of lead and antimony.

"This article is brought from Naples for the moft part in the form of an earthy cruft about three or four lines in thicknefs, and it fometimes retains the form of the veffel in which it has hardened. It can be procured alfo as a fine powder, as the colourmen keep it fometimes ready pounded for ufe."

About the nature of the fubftance called Naples-yellow there has been much diverfity of opinion. Moft of thofe who have written about it, confider it as originating from fire, and as a volcanic production of Mount Vefuvius or Mount Ætna; others have pronounced it to be a natural ochre. Guettard thought it rather a kind of bole; but Pott approached neareft the truth, by afferting it to be an artificial preparation *. Fougeroux is entitled to the merit of having proved this, and of having fhewn the poffibility of preparing it. According to his experiments, Naples-yellow will be obtained if you boil for feven or eight hours, firft over a flow and then over a ftrong fire, a mixture finely pulverifed of twelve parts of pure white lead, one part of alum, one part of fal ammoniac, and three parts of diaphoretic antimony † (white oxide of antimony by nitre). But before Fougeroux, who may have obtained an account of the procefs during his travels through Italy, a more certain procefs was publifhed in the year 1758, by Giambattifta Pafferi, in his interefting work on the painting of earthen ware ‡. The articles to be employed, according to this author, are, "one pound of antimony, a pound and a half of lead, one ounce of *alume di feccia*, and the fame quantity of common falt." I am inclined (fays M. Beckmann) to think that this receipt was not unknown to Fougeroux, and that he confidered *alume di feccia* to be alum. Profeffor Leonhardi, a man of very found learning, has tranflated this expreffion by the word alum. I will, however, freely confefs, that I confider *alume di feccia* not to mean alum, but falt of tartar, or potafh. Pafferi

* *Lithogeognofie*, v. ii. p. 15.

† *Mem. of the Acad. of Sciences*, 1766.

‡ *In Nuova raccolta d'opufculi fcientifici*, t. iv.

Naples, Nardus.

feri says, that the proportions may be varied different ways; and he gives six other receipts, in which he does not mention *alume di feccia*, but only *feccia;* and this word certainly means *weinhefen* or winestone (tartar). Professor Leonhardi himself seems to confirm this opinion, by saying, that Vairo, professor of chemistry at Naples, has translated "the ashes of wine lees" *(cineres infectorii)* by the words *alume di feccia.*

After Fougeroux's paper was printed, De la Lande published a receipt which he had received from the well-known prince San Severo, and in which lead and antimony only are employed; but no mention is made either of alum, tartar, or any other salt. This receipt is as follows:

Take lead well calcined and sifted, with a third part of its weight of antimony pounded and sifted also. Mix these substances well together, and sift them again through a piece of silk. Then take large flat earthen dishes, not varnished, cover them with white paper, and spread out the powder upon them to the depth of about two inches. Place these dishes in a potter's furnace, but only at the top, that they may not be exposed to too violent a heat. The reverberation of the flame will be sufficient. The dishes may be taken out at the same time as the earthen-ware, and the substance will then be found hard, and of a yellow colour. It is then pounded on a piece of marble with water, and afterwards dried for use.

The enamel painters in Germany prepare a yellow glazing, not very different from the real Naples yellow, by a prescription, according to which, "one pound of antimony, six ounces of red lead, and two ounces of white sand, are to be fused together. The produce, which appears quite black, is to be pounded, and then fused again; and this process is to be repeated till the whole mass becomes thoroughly yellow. Half a pound of this mass is to be mixed with two ounces of red lead, and afterwards fused; and by this tedious process an orange-yellow pigment will be obtained."

All artists who speak of the use of Naples yellow, give cautions against applying iron to it, as the colour by these means becomes greenish, or at least dirty. For this reason, it must be pounded on a stone, and scraped together with an ivory spatula. It is employed chiefly in oil painting, because the colour is softer, brighter, and richer than that of ochre, yellow lead, or orpiment, and because it far exceeds these pigments in durability. It is employed in particular when the yellow ought to have the appearance of gold, and in this respect it may be prepared with gum water, and used as a water colour. A still greater advantage of it is, that it is proper for enamel painting, and on that account may be employed on porcelain or earthen ware (A). Professor Beckmann, however, recommends to artists to examine whether the oxide prepared from wolfram, by boiling in the muriatic acid, which has a beautiful yellow colour, might not be used in the same manner as Naples yellow.

NARDUS. Under this generic term we have, in the *Encyclopædia*, given, from the *Philosophical Transactions*, a description of the plant or grass which Dr Blane considers as the spikenard of the ancients. It is our duty, in this place, to inform our readers, that Sir William Jones, in the 2d and 4th volumes of the *Asiatic Researches*, seems to have completely proved that the spikenard of Dioscorides and Galen, or *Nardus Indica*, was a very different plan from the Andropogon of Dr Blane, and that it grows in a country far distant from *Mackran*. The proofs brought by the illustrious president of the Asiatic Society, in support of his own opinion, are too numerous and circumstantial to be introduced into such a work as this. We shall therefore only give one of them; which though, when separated from the rest, it loses much of its force, must be allowed, even singly, to have great weight.

Nardus, Nares.

The true Indian spikenard is confessedly called by the Arabs *Sumbulu'l Hind;* for so they translate the name of it in Dioscorides. Now (says Sir William) I put a fair and plain question severally to three or four Mussulman physicians: "What is the Indian name of the plant which the Arabs call *Sumbulu'l Hind?*" They all answered, but some with more readiness than others, *Játámansí*. After a pretty long interval, I shewed them the spikes (as they are called) of *Játámansí*, and asked, what was the Arabic name of that Indian drug? They all answered readily, *Sumbulu'l Hind*. The same evidence may be obtained in this country by any other European who seeks it; and if among twelve native physicians, versed in Arabian and Indian philology, a single man should, after due consideration, give different answers, I will cheerfully submit to the Roman judgment of *non liquet*. But the *Játámansí* * evidently belongs to the natural order which Linnæus calls *aggregate;* with the following *characters:* * Plate XXX.

Calyx, scarce any; *margin*, hardly discernible. *Corolla*, one petal; *tube* somewhat gibbous; *border* five cleft. *Stamina*, three *Anthers*. *Pistula*, *Germ* beneath; one *Style* erect. *Seed*, solitary, crowned with a pappus. *Root*, fibrous. *Leaves*, hearted, fourfold; *radical* leaves petioled.

It appears therefore (continues the learned author) to be the Protean plant Valerian, a sister of the Mountain and Celtick Nard, and of a species which I should describe in the Linnean style, *Valeriana Játámansí floribus triandris, foliis cordatis quaternis, radicalibus petiolatis.* The radical leaves, rising from the ground, and enfolding the young stem, are plucked up with a part of the root, and being dried in the sun or by an artificial heat, are sold as a drug, which, from its appearance, has been called spikenard. The Játámansí is a native of the most remote and hilly parts of India, such as NE'PA'L, Marang Butan, near which Ptolemy fixes the native soil of the *Nardus Indica*. It grows erect above the surface of the ground resembling an ear of green wheat; and when recent, it has a faint odour, which is greatly increased by the simple process of drying it.

NARES (JAMES), doctor of music, an eminent composer and teacher in that science, under whom some of the first musicians of the present day received the whole or part of their education, was the son of Mr Nares, who was, for many years, steward to Montague and Biog. Dict. new edit.

(A) In the Memoirs of the Academy of Sciences for 1767, Fougeroux has proved that the giallolino prepared by him produced on porcelain a much more beautiful colour than the Naples yellow sold in the shops.

Nares.

and Willoughby, earls of Abingdon. He was born, as well as his brother, the late Mr Juſtice Nares, at Stanwell in Middleſex; the former in 1715, the latter in 1716. His muſical education he commenced under Mr Gates, then maſter of the royal choriſters; and completed it under the celebrated Dr Pepuſch. Thus prepared, he officiated, for ſome time, as deputy to Mr Pigott, organiſt of Windſor; but on the reſignation of Mr Saliſbury, organiſt of York, in 1734, was choſen to ſucceed him, being then only nineteen. It is related, on undoubted authority, that when the old muſician firſt ſaw his intended ſucceſſor, he ſaid, rather angrily, "What! is that child to ſucceed me?" which being mentioned to the organiſt-elect, he took an early opportunity, on a difficult ſervice being appointed, to play it throughout half a note below the pitch, which brought it into a key with ſeven ſharps; and went through it without the ſlighteſt error. Being aſked why he did ſo? he ſaid, that "he only wiſhed to ſhew Mr Saliſbury what a child could do." His knowledge in all branches of his profeſſion was equal to his practical ſkill in this inſtance; and, during his reſidence at York, where he was abundantly employed as a teacher, and where he married, Mr Nares, by his good conduct, as well as profeſſional merit, obtained many powerful friends. Among the foremoſt of theſe was Dr Fontayne, the reſpectable and venerable dean of York; who, when Dr Green died, towards the letter end of 1755, exerted his intereſt ſo ſuccesſfully, that he obtained for him the united places of organiſt and compoſer to his Majeſty. He removed therefore to London in the beginning of 1756; and, about the ſame time, was created doctor in muſic at Cambridge.

On the reſignation of Mr Gates, in 1757, Dr Nares obtained alſo the place of maſter of the choriſters; which having been, for a long time, without increaſe, notwithſtanding the increaſe of expences attending it, was, by royal favour, augmented about 1775, firſt with the ſalary of the violiſt; and, on the revival of that place for Mr Croſdill, in 1777, with that of lutaniſt, which was annexed to it for ever. It was in this ſituation that Dr Nares ſuperintended the education of many pupils, who have ſince become famous; particularly Dr Arnold, who, though with him only for a ſhort time, was highly diſtinguiſhed by him for talents and application. The anthems and ſervices which Dr Nares produced, as compoſer to the royal chapel, were very numerous; many of them have ſince been printed, and many which exiſt only in manuſcript ſtill continue to be performed in the choirs with much effect. Having been originally a muſician rather by accident than choice, with very ſtrong talents and propenſities alſo for literature, Dr Nares was particularly attentive to expreſs the ſenſe of the words he undertook to ſet; and was the firſt who attempted to compoſe the Te Deum for the choir ſervice, in ſuch a manner as to ſet off the ſentiments it contains to advantage. Before his time, it had been ſet rather to a regular ſtrain of chaunt than to any expreſſive melodies. The merits of Dr Nares were not overlooked by his royal patrons, whom he had occaſionally the honour to attend in private, though not a part of his regular duty. To manifeſt his reſpect and gratitude for them, he compoſed his dramatic ode, entitled The Royal Paſtoral; the words of which were written by Mr Bellamy, author of a book, entitled Ethic Amuſements.

In July 1780, Dr Nares was obliged, by declining health, to reſign the care of the choriſters, in which place he was ſucceeded by Dr Ayrton, his pupil and valued friend. In his ſixty-eighth year, a conſtitution, never robuſt, gave way, and he died on February 10. 1783. Teſtimony has been borne to the merits of Dr Nares by ſeveral writers, but more particularly by Mr Maſon, in his preface to a book of anthems, printed for the uſe of York Cathedral; and in his late Eſſays on Church Muſic, page 138. The late Lord Mornington, ſo well known for muſical talents, frequently conſulted him; and Sir John Hawkins derived advantage from his acquaintance, in the progreſs of his Hiſtory of Muſic. Throughout life, he was not leſs reſpected as a man than admired as a muſician; he had a vivacity that rendered his ſociety always pleaſing; and a generous contempt for every thing baſe, that manifeſted itſelf on all proper occaſions, and very juſtly commanded eſteem.

His printed works are theſe: 1. Eight ſets of Leſſons for the Harpſichord; dedicated to the Right Hon. Willoughby Earl of Abingdon. Printed in 1748; reprinted in 1757. 2. Five Leſſons for the Harpſichord, with a Sonata in ſcore for the Harpſichord or Organ; dedicated to the Right Honourable the Counteſs of Carliſle; publiſhed in 1758 or 1759. 3. A Set of Eaſy Leſſons for the Harpſichord, three in number; with a dedication to the public, ſigned J. N. 4. A Treatiſe on Singing, ſmall ſize. 5. Il Principio; or A regular Introduction to playing on the Harpſichord or Organ. This was the firſt ſet of progreſſive leſſons publiſhed on a regular plan. 6. The Royal Paſtoral, a Dramatic Ode; dedicated to his Royal Highneſs the Prince of Wales; printed in ſcore, with an overture and choruſes. 7. Catches, Canons, and Glees; dedicated to the late Lord Mornington. 8 Six Fugues, with Introductory Voluntaries for the Organ or Harpſichord. 9. A Conciſe and Eaſy Treatiſe on Singing, with a Set of Engliſh Duets for Beginners. A different work from the former ſmall treatiſe. 10. Twenty Anthems, in ſcore, for one, two, three, four, and five Voices. Compoſed for the Uſe of his Majeſty's Chapels Royal, 1778. 11. Six Eaſy Anthems, with a favourite Morning and Evening Service, left for publication at his death, and publiſhed in 1788, with a portrait and a conciſe account of the author. Of theſe compoſitions the following ſhort character is given by an eminent muſician, to whom they are all well-known: "The leſſons are compoſed in a maſterly and pleaſing ſtyle; free from thoſe tricks and unmeaning ſucceſſions of ſemitones, to which a good ear and ſound judgment never can be reconciled. The treatiſes on ſinging contain duets compoſed for the uſe of the children of the royal chapels, ſuperior to any thing yet publiſhed; and ſuch as every teacher ought to peruſe. His catches, canons, and glees, are natural and pleaſing; eſpecially the glee to all Lovers of Harmony, which gained the prize medal at the catch-club in 1770. The Royal Paſtoral is compoſed throughout in a very maſterly manner; particularly the choruſes, with which each part concludes. This ode, containing 108 pages, was written, and all the vocal and inſtrumental parts tranſcribed for performing, within twelve days. The

ſix

Navigators. fix fugues, with introductory voluntaries for the organ, contain the ftrongeft proofs of ingenuity and judgement; few, if any, have ever been written that can be preferred to them. In both fets of the anthems, the fame characteriftics appear; and the fervice of the latter very juftly acquired the title of *favourite*; nor can there be any doubt that the works of this author will be admired as long as a tafte for mufic fhall fubfift."

NAVIGATORS ISLANDS, an archipelago in the South Sea, difcovered by Bougainville, who gave to them that name, becaufe the natives do not pafs between the different villages, which are all built in creeks and bays, but in their canoes. The Navigators Iflands are ten in number; namely, *Opoun*, *Leoné*, *Fanfoué*, MAOUANA, *Oyolava*, *Calinaffé*, *Pola*, *Shika*, *Offamo*, and *Ouera*.

We have already given an account of the foil and productions of MAOUANA; and as the other iflands of this clufter are equally fertile, we need not go over the fame ground again. It may be proper, however, to obferve, that in fome of them the fugar-cane was found growing fpontaneoufly, though its juice contained lefs of the faccharine fubftance than the fugar cane of the Weft Indies, which our voyagers attributed to its growing in a richer foil and in the fhade. According to Peroufe, the Navigators Iflands are fituated about the 14th degree of fouth latitude, and between the 171ft and 175th degrees of longitude weft from Paris. In Oyolava the fmoke was feen hovering over a village as over a large European town; and the number of canoes which from that ifland furrounded the frigates was immenfe. Thefe are very ticklifh veffels, and would be abfolutely ufelefs to any body but fuch excellent fwimmers as the iflanders, who are no more furprifed or uneafy at their overfetting than we are at the fall of a hat. Taking up the canoe on their fhoulders, they empty it of water, and then get in again, with the certainty of having the fame operation to perform a fecond time in half an hour. Sometimes they join two canoes together by means of a crofs piece of wood, in which they make a ftep to receive the maft; and in this way they are lefs liable to be overfet, fometimes performing a long voyage without any fuch accident. It is needlefs to add, that thefe canoes are very fmall, generally containing only five or fix perfons, though fome few of them may contain as many as fourteen.

The natives of the Navigators Iflands are tall and well made. Their ufual height is five feet nine, ten, and eleven inches; but their ftature is lefs aftonifhing than the coloffal proportions of the different parts of their bodies. "Our curiofity (fays Peroufe), which often led us to meafure them, gave them an opportunity of making frequent comparifons of their bodily ftrength with ours. Thefe comparifons were not to our advantage; and we perhaps owe our misfortunes (fee MAOUANA in this *Suppl.*) to the idea of individual fuperiority refulting from repeated trials. Their countenances often appeared to exprefs a fentiment of difdain, which I hoped to deftroy, by ordering our arms to be ufed in their prefence: but my end could only have been gained by directing them againft human victims; for otherwife they took the noife for fport, and the trial for a diverfion.

"Among thefe Indians a very fmall number is below the height indicated above. I have, however, meafured feveral who were only five feet four inches, but Navigators thefe are the dwarfs of the country; and although their ftature refembles ours, their ftrong and nervous arms, their broad chefts, and their legs and thighs, are of a very different proportion.

"The men have the body painted or tatowed, fo that any one would fuppofe them clad, although they go almoft naked. They have only a girdle of feaweeds encircling their loins, which comes down to their knees, and gives them the appearance of the river gods of fabulous hiftory, whom it is cuftomary to depict with rufhes round their waift. Their hair is very long. They often twift it round their heads, and thus add to their native ferocity of countenance, which always expreffes either furprife or anger. The leaft difpute between them is followed by blows of fticks, clubs, or paddles; and often, without doubt, cofts the combatants their lives. They are almoft all covered with fcars, which can only be the confequence of their individual quarrels. The ftature of the women is proportioned to that of the men. They are tall, flender, and not without grace; but they lofe, while yet in their prime, thofe elegant forms, of which Nature has not broken the mould among this barbarous race, but of which fhe appears to leave them in poffeffion only for a moment, and with reluctance. Among a great number of women that I had an opportunity of feeing, I only obferved three really pretty. The grofs effrontery of the reft, the indecency of their motions, and the difgufting offers which they made of their favours, rendered them fit mothers and wives for the ferocious beings that furrounded us." Our author gives the following inftance of indecent manners, which is, perhaps, without a parallel.

The young and prettieft females foon attracted the attention of feveral Frenchmen, who, in fpite of the Commodore's prohibition, endeavoured to form a connection with them, and were fuccefsful. The looks of the Europeans expreffing defires which were foon divined, fome old women undertook the negociation. The altar was prepared in the handfomeft hut in the village, all the blinds were let down, and the inquifitive were excluded. The victim was then laid in the arms of an old man, who exhorted her, during the ceremony, to moderate the expreffion of her pain; while the matrons fang and howled: the ceremony being performed in their prefence. and under the aufpices of the old man, who ferved at once as prieft and altar. All the women and children in the village were round the houfe, gently lifting up the blinds, and feeking to enjoy the fight through the fmalleft crevices in the mats. Whatever former navigators may have faid, Peroufe was convinced that, in the Navigators Iflands at leaft, the young girls, before they are married, are miftreffes of their perfons, and that they are not difhonoured by their complaifance. It is even more than probable, that in marrying they are called to no account concerning their paft conduct; but he had no doubt that they are obliged to be more referved when provided with a hufband.

Thefe people cultivate certain arts with fuccefs. Under the article MAOUANA mention has been made of the elegant form which they give to their huts. It is not with fuch folly as is commonly fuppofed that they difdain our inftruments of iron; for they finifh their work very

Navigators.

very neatly with tools made of a very fine and compact species of basaltes in the form of an adze. For a few glass beads they sold to Perouse large three-legged dishes of a single piece of wood, and so well polished that they seemed to have been laid over with a coat of the finest varnish. It would take an European workman several days to produce one of these dishes, which, for want of proper instruments, must cost an Indian several months labour. They set, however, scarcely any value upon them, because they set little upon the time they employ. The fruit trees and nutritious roots that grow spontaneously around them, insure to them their subsistence, as well as that of their hogs, dogs, and fowls; and if they sometimes stoop to work, it is to procure enjoyments rather agreeable than useful. They manufacture very fine mats, and some paper stuffs. Our author remarked two or three of them, whom he took for chiefs, with a piece of cloth tied round their waist like a petticoat, instead of a girdle of weeds. It is composed of real thread, prepared no doubt from some filamentous plant like the nettle or flax; and is manufactured without a shuttle, the threads being absolutely laid over one another like those of their mats. This cloth, which has all the suppleness and solidity of ours, is very fit for the sails of their canoes; and appeared far superior to the paper stuff of the Society and Friendly Islands, which they manufacture also. Their canoes are well constructed, and furnish a good proof of the skill with which they work in wood. For a few glass beads they gave to the Frenchmen, among other things, a wooden vessel filled with cocoa nut oil, exactly of the shape of our earthen pots, and such as no European would undertake to fashion by any other means than a turning lathe. Their ropes are round, and twisted like watch chains of ribbon: their mats are very fine; but their stuffs are inferior to those of the Easter and Sandwich Islands.

Perouse derives the natives of those islands, whose colour, he says, nearly resembles that of the Algerines and other nations on the coast of Barbary, from the Malays; and as we do not vouch for the truth of his theory, though we admit it to be ingenious, we shall give the reasoning by which he supports it in his own words.

"We did not at first discover (says he) any identity between their language and that of the natives of the Society and Friendly Islands, of which we had vocabularies; but a more mature examination convinced us, that they speak a dialect of the same language. A fact which tends to prove it, and which confirms the opinion of the English concerning the origin of these people, is, that a young domestic, a native of the province of Tagayan in the north of Manilla, understood and explained to us the greater part of their words. It is well known that the Tagayan, the Talgal, and the generality of languages spoken in the Philippines, are derived from the Malay: a language more diffused than were those of the Greeks and Romans, and common to the numerous tribes that inhabit the islands of the great Pacific Ocean. It appears to me evident, that all these different nations are the progeny of Malay colonies, which, in some age extremely remote, conquered the islands they inhabit. I should not even wonder, if the Chinese and Egyptians, whose antiquity is so much vaunted, were mere moderns in comparison of the Malays. But however this may be, I am satisfied that the aborigines of the Philippine Islands, Formosa, New Guinea, New Britain, the New Hebrides, the Friendly Islands, &c. in the southern hemisphere, and those of the Marianna and Sandwich islands in the northern, were that race of woolly headed men still found in the interior of the islands of Luconia and Formosa. They were not to be subjugated in New Guinea, New Britain, and the New Hebrides; but being overcome in the more eastern islands, which were too small to afford them a retreat in the centre, they mixed with the conquering nation. Thence has resulted a race of very black men, whose colour is still several shades deeper than that of certain families of the country, probably because the latter have made it a point of honour to keep their blood unmixed. I was struck with these two very distinct races in the Islands of Navigators, and cannot attribute to them any other origin.

"The descendants of the Malays have acquired in those islands a degree of vigour and strength, a lofty stature, and a Herculean form, which they do not inherit from their forefathers, but which they owe, without doubt, to an abundance of food, to a mild climate, and to the influence of different physical causes which have been constantly acting during a long series of generations. The arts which they perhaps brought with them may have been lost for want of materials and instruments to practise them; but the identity of language, like Ariadne's clue, enables the observer to follow all the windings of this new labyrinth. The feudal government is also preserved here; that government which little tyrants may regret; which was the disgrace of Europe for several centuries; and of which the Gothic remains are still to be found in our laws, and are the medals that attest our ancient barbarism: that government, which is the most proper to keep up a ferocity of manners, because the smallest disputes occasion wars of village against village, and because wars of this nature are conducted without magnanimity, and without courage. Surprises and treachery are employed by turns; and in these unfortunate countries, instead of generous warriors, nothing is to be found but base assassins (A). The Malays are still the most perfidious nation

(A) This was written under the old government of France by a man who, like other declaimers in the cause of liberty, forgot the excellencies, and insisted only on the defects of the feudal institutions. Had Perouse, however, returned to Europe, and witnessed the *philosophic* government of his country, he would have perceived, that *liberty* and *equality*, and *the rights of man*, are as well calculated to generate base assassins, as the Gothic remains of that Government by which he supposed Europe to have been so long disgraced. He might even have lived to regret, that his lot was not cast among the bold and ferocious inhabitants of Maouna; for the treachery and cruelty of these people bears no proportion, even in his affecting narrative, to the systematic cruelty of those who decreed, that the end sanctifies the means, and that nothing, however atrocious in the estimation of antiquated moralists, is to be omitted, which contributes to elevate the mean above the noble.

tion of Asia; and their children have not degenerated, because the same causes have led to and produced the same effects. It may be objected, perhaps, that it must have been very difficult for the Malays to make their way from west to east, to arrive at these different islands; but the westerly winds blow as frequently as the easterly in the vicinity of the equator, along a zone of seven or eight degrees from north to south, where the wind is so variable, that it is hardly more difficult to navigate east than west. Besides, these different conquests may not have been effected at the same time: the people in question may, on the contrary, have spread themselves by little and little, and gradually have introduced that form of government which still exists in the peninsula of Malacca, at Java, Sumatra, and at Borneo, as well as in all the other countries subject to that barbarous nation."

NAZER, Nazr, Nezer, Nuzzer, Nuzzerana; a present from an inferior; fees of office.

NEBULOUS, or Cloudy, a term applied to certain fixed stars which shew a dim hazy light; being less than those of the sixth magnitude, and therefore scarcely visible to the naked eye, to which at best they only appear like little dusky specks or clouds. Through a moderate telescope, these nebulous stars plainly appear to be congeries or clusters of several little stars.

NECKAR Isle, a small barren island, or rather rock, discovered by Perouse in the Pacific Ocean. Though its sterility renders it of no importance in itself, its exact situation must be interesting to navigators, who are therefore obliged to the French Commodore for having ascertained its latitude to be 23° 34′ north, and its longitude to be 166° 52′ west from Paris. From the soundings the *Neckar* seemed to be only the top or nucleus of a much more considerable island, which, probably from being composed of a soft and dissoluble substance, the sea had gradually washed away. In proportion as the frigates left the shore, the depth, which at the distance of a mile was very little, gradually increased, till, at the distance of about ten miles, no bottom was found with a line of 150 fathoms; and over the whole of that shore the bottom consisted of coral and broken shells.

NEPAL, a kingdom of India, situated to the north-east of the city of Patna, at the distance of ten or twelve days journey. Within the distance of four days journey from Nepal the road is good in the plains of Hindostan, but in the mountains it is bad, narrow, and dangerous. At the foot of the hills the country is called *Teriani;* and there the air is very unwholesome from the middle of March to the middle of November; and people in their passage catch a disorder called in the language of that country *aul;* which is a putrid fever, and of which the generality of people, who are attacked with it, die in a few days; but on the plains there is no apprehension of it. Although the road be very narrow and inconvenient for three or four days at the passes of the hills, where it is necessary to cross and recross the river more than fifty times, yet, on reaching the interior mountain before you descend, you have an agreeable prospect of the extensive plain of Nepal, resembling an amphitheatre covered with populous towns and villages: the circumference of the plain is about 200 miles, a little irregular, and surrounded by hills on all sides, so that no person can enter or come out of it without passing the mountains.

There are three principal cities in the plain, each of which was the capital of an independent kingdom; the principal city of the three is situated to the northward of the plain, and is called *Cat'hmandu:* it contains about 18,000 houses; and this kingdom, from south to north, extends to the distance of twelve or thirteen days journey as far as the borders of Tibet, and is almost as extensive from east to west. The king of Cat'hmandu has always about 50,000 soldiers in his service. The second city to the south-west of Cat'hmandu is called *Lelit Pattan;* it contains near 24,000 houses. The third principal city to the east of Lelit Pattan is called *B'hatgan;* it contains about 12,000 families; and is the metropolis of a district which extends towards the east to the distance of five or six days journey; and borders upon another nation, also independent, called *Ciratas*, who profess no religion. Besides these three principal cities, there are many other large and less considerable towns or fortresses; one of which is *Timi*, and another *Cipoli*, each of which contains about 8000 houses, and is very populous. All those towns, both great and small, are well built; the houses are constructed of brick, and are three or four stories high; their apartments are not lofty; they have doors and windows of wood well worked and arranged with great regularity. The streets of all their towns are paved with brick or stone, with a regular declivity to carry off the water. In almost every street of the capital towns there are also good wells made of stone, from which the water passes through several stone canals for the public benefit. In every town there are large square varandas well built, for the accommodation of travellers and the public: these varandas are called *Pali;* and there are also many of them, as well as wells, in different parts of the country for public use. There are also, on the outside of the great towns, small square reservoirs of water, faced with brick, with a good road to walk upon, and a large flight of steps for the convenience of those who choose to bathe.

The religion of Nepal is of two kinds: the more ancient is professed by many people who call themselves *Baryesu;* they pluck out all the hair from their heads; their dress is of coarse red woollen cloth, and they wear a cap of the same; they are considered as people of the religious order, and their religion prohibits them from marrying, as it is with the Lamas of Tibet, from which country their religion was originally brought; but in Nepal they do not observe this rule, except at their discretion. They have large monasteries, in which every one has a separate apartment or place of abode. They observe also particular festivals, the principal of which is called *Yatra* in their language, and continues a month or longer according to the pleasure of the king. The ceremony consists in drawing an idol, which at Lelit Pattan is called *Baghero*, in a large and richly ornamented car, covered with gilt copper: round about the idol stand the king and the principal Baryesus; and in this manner the vehicle is almost every day drawn thro' some one of the streets of the city by the inhabitants, who run about beating and playing upon every kind of instrument their country affords, which make an inconceivable noise.

The

The other religion, the more common of the two, is that of the Brahmens, and is the fame as is followed in Hindoftan, with the difference that, in the latter country, the Hindus being mixed with the Mahommedans, their religion alfo abounds with many prejudices, and is not ftrictly obferved; whereas in Nepal, where there are no Muffelmans (except one Cafhmirian merchant), the Hindu religion is practifed in its greateft purity: every day of the month they clafs under its proper name, when certain facrifices are to be performed and certain prayers offered up in their temples: the places of worfhip are more in number in their towns than are to be found in the moft populous and moft flourifhing cities of Chriftendom; many of them are magnificent according to their ideas of architecture, and conftructed at a very confiderable expence; fome of them have four or five fquare cupolas, and in fome of the temples two or three of the extreme cupolas, as well as the doors and windows of them, are decorated with gilt copper.

In the city of Lelit Pattan the temple of Baghero is more valuable, on account of the gold, filver, and jewels it contains, than even the houfe of the king. Befides the large temples, there are alfo many fmall ones, which have ftairs, by which a fingle perfon may afcend, on the outfide all around them; and fome of thofe fmall temples have four fides, others fix, with fmall ftone or marble pillars polifhed very fmooth, with two or three pyramidal ftories, and all their ornaments well gilt, and neatly worked according to their ideas of tafte. On the outfide of fome of their temples there are great fquare pillars of fingle ftones from twenty to thirty feet high, upon which they place their idols fuperbly gilt. The greateft number of their temples have a good ftone ftaircafe in the middle of the four fquares, and at the end of each flight of ftairs there are lines cut out of ftone on both fides: around about their temples there are alfo bells, which the people ring on particular occafions; and when they are at prayers, many cupolas are alfo quite filled with little bells hanging by cords in the infide about the diftance of a foot from each other, which make a great noife on that quarter where the wind conveys the found. There are not only fuperb temples in their great cities, but alfo within their caftles.

To the eaftward of Cat'hmandu, at the diftance of about two or three miles, there is a place called *Tolu*, by which there flows a fmall river, the water of which is efteemed holy, according to their fuperftitious ideas, and thither they carry people of high rank, when they are thought to be at the point of death: at this place there is a temple, which is not inferior to the beft and richeft in any of the capital cities. They alfo have it on tradition, that at two or three places in Nepal valuable treafures are concealed under ground: one of thofe places they believe is Tolu; but no one is permitted to make ufe of them except the king, and that only in cafes of neceffity. Thofe treafures, they fay, have been accumulated in this manner: When any temple had become very rich from the offerings of the people, it was deftroyed, and deep vaults dug under ground one above another, in which the gold, filver, gilt copper, jewels, and every thing of value, were depofited. This was found to be actually the cafe when the miffionary, from whofe memoir this account of Nepal is taken, was at Cat'hmandu. One of the kings, or pretenders to the crown, who were then at war with each other, being in the utmoft diftrefs for want of money to pay his troops, ordered the vaults at Tolu to be opened; and found in the firft vault more money, befides filver and gold idols, than he had immediate occafion for.

To the weftward alfo of the great city of Lelit Pattan, at the diftance of only three miles, is a caftle called *Banga*, in which there is a magnificent temple. No one of the miffionaries ever entered into this caftle; becaufe the people who have the care of it, have fuch a fcrupulous veneration for the temple, that no perfon is permitted to enter it with his fhoes on; and the miffionaries, unwilling to fhew fuch refpect to their falfe deities, never entered it. The author of this memoir, however, who acted as phyfician to the commandant, was of courfe admitted within the caftle, and got a fight of the celebrated temple, which he declares that for magnificence he believes fuperior to every thing in Europe.

Befides the magnificence of the temples, which their cities and towns contain, there are many other rarities. At Cat'hmandu, on one fide of the royal garden, there is a large fountain, in which is one of their idols called *Narayan*. This idol is of blue ftone, crowned and fleeping on a mattrafs alfo of the fame kind of ftone, and the idol and the mattrafs appear as floating upon the water. This ftone machine is very large, being about 18 or 20 feet long, and broad in proportion, but well worked, and in good repair.

In a wall of the royal palace of Cat'hmandu, which is built upon the court before the palace, there is a great ftone of a fingle piece, which is about fifteen feet long, and four or five feet thick; on the top of this great ftone there are four fquare holes at equal diftances from each other; in the infide of the wall they pour water into the holes; and in the court fide, each hole having a clofed canal, every perfon may draw water to drink. At the foot of the ftone is a large ladder, by which people afcend to drink; but the curiofity of the ftone confifts in its being quite covered with characters of different languages cut upon it. Some lines contain the characters of the language of the country, others the characters of Tibet, others Perfian, others Greek, befides feveral others of different nations; and in the middle there is a line of Roman characters, which appears in this form, AVTOMNEW INTER LHIVERT; but none of the inhabitants have any knowledge how they came there, nor do they know whether or not any European had ever been in Nepal before the miffionaries, who arrived there only the beginning of the prefent century. They are manifeftly two French names of feafons, with an Englifh word between them.

There is alfo to the northward of the city of Cat'hmandu a hill called *Simbi*, upon which are fome tombs of the Lamas of Tibet, and other people of high rank of the fame nation. The monuments are conftructed after various forms: two or three of them are pyramidal, very high, and well ornamented; fo that they have a very good appearance, and may be feen at a confiderable diftance. Round thefe monuments are remarkable ftones covered with characters, which probably are the infcriptions of fome of the inhabitants of Tibet, whofe bones were interred there. The natives of Nepal not only look upon the hill as facred, but imagine it is protected by their idols; and from this erroneous fuppofition never think of ftationing troops there for the

Newton. defence of it, although it be a poſt of great importance, and only at a ſhort mile's diſtance from the city. During the hoſtilities, however, which prevailed when our author was in the country, this ſacred hill was fortified by one of the armies, who, in digging their ditches among the tombs, found conſiderable pieces of gold, with a quantity of which metal the corpſes of the grandees of Tibet are always interred.

The kingdom of Nepal our author believes to be very ancient, becauſe it has always preſerved its peculiar language and independence. It was completely ruined, however, about thirty or forty years ago by the diſſenſions of its nobles, who, on the death of their ſovereign, and, as it would ſeem, the extinction of the royal line, could not agree in their choice of a proper ſucceſſor. The conſequence was, that different ſovereigns were ſet up by the nobles of different diſtricts; and theſe waged war with each other, with a degree of treachery and ſavage atrocity that has hardly a parallel in the annals of the world. Even the Brahmens, whom we are accuſtomed to conſider as a mild and innocent people, were, in the civil wars of Nepal, guilty of the meaneſt and baſeſt villanies: they brought about treaties between the rival ſovereigns, and then encouraged him whom they favoured, to maſſacre the adherents of the other in cold blood.

NEWTON (John), an eminent Engliſh mathematician, was born at Oundle in Northamptonſhire, 1622. After a proper foundation at ſchool, he was ſent to Oxford, where he was entered a commoner of St Edmund's Hall in 1637. He took the degree of bachelor of arts in 1641; and the year following was created maſter, among ſeveral gentlemen that belonged to the king and court, then reſiding in the univerſity. At which time, his genius being inclined to aſtronomy and the mathematics, he applied himſelf diligently to thoſe ſciences, and made a great proficiency in them, which he found of ſervice during the times of the uſurpation. After the reſtoration of Charles II. he reaped the fruits of his loyalty; being created doctor of divinity at Oxford Sept. 1661, he was made one of the king's chaplains, and rector of Roſs in Herefordſhire, in the place of Mr John Toombes, ejected for nonconformity. He held this living till his death, which happened at Roſs on Chriſtmas-day 1678. Mr Wood gives him the character of a capricious and humourſome perſon: however that may be, his writings are ſufficient monuments of his genius and ſkill in the mathematics. Theſe are, 1. *Aſtronomia Britannica*, &c. in three parts, 1656, in 4to. 2. Help to Calculation; with Tables of Declination, Aſcenſion, &c. 1657, 4to. 3. *Trigonometria Britannica*, in two books, 1658, folio; one compoſed by our author, and the other tranſlated from the Latin of Henry Gellibrand. 4. *Chiliades centum Logarithmorum*, printed with, 5. Geometrical Trigonometry, 1659. 6. Mathematical Elements, three parts, 1660, 4to. 7. A perpetual Diary or Almanack, 1662. 8. Deſcription of the uſe of the Carpenter's Rule, 1667. 9. Ephemerides, ſhewing the Intereſt and rate of Money at 6 *per cent.* &c. 1667. 10. *Chiliades centum Logarithmorum, et Tabula Partium proportionalium*, 1667. 11. The Rule of Intereſt, or the caſe of Decimal Fractions, &c. Part II. 1668, 8vo. 12. School Paſtime for young Children, &c. 1669, 8vo. 13. Art of practical Gauging, &c. 1669. 14. Introduction to the Art of Rhetoric, 1671. 15. The Art of Natural Arithmetic, in whole Numbers, and Fractions Vulgar and Decimal, 1671, 8vo. 16. The Engliſh Academy, 1677, 8vo. 17. Coſmography. 18. Introduction to Aſtronomy. 19. Introduction to Geography, 1678, 8vo *.

Nicole. * Biog. Dict. new edit.

NICOLE (Francis), a very celebrated French mathematician, was born at Paris December 23. 1683. His early attachment to the mathematics induced M. Montmort to take the charge of his education; and he opened out to him the way to the higher geometry. He firſt became publicly remarkable by detecting the fallacy of a pretended quadrature of the circle. This quadrature a M. Mathulon ſo aſſuredly thought he had diſcovered, that he depoſited, in the hands of a public notary at Lyons, the ſum of 3000 livres, to be paid to any perſon who, in the judgment of the Academy of Sciences, ſhould demonſtrate the falſity of his ſolution. M. Nicole, piqued at this challenge, undertook the taſk, and expoſing the paralogiſm, the Academy's judgment was, that Nicole had plainly proved that the rectilineal figure which Mathulon had given as equal to the circle, was not only unequal to it, but that it was even greater than the polygon of 32 ſides circumſcribed about the circle. The prize of 3000 livres Nichole preſented to the public hoſpital of Lyons.

The Academy named Nicole, Eleve-Mechanician, March 12. 1707; Adjunct in 1716, Aſſociate in 1718, and Penſioner in 1724; which he continued till his death, which happened the 18th of January 1758, at 75 years of age.

His works were all inſerted in the different volumes of the Memoirs of the Academy of Sciences; and are as follow: 1. A General Method for determining the Nature of Curves formed by the Rolling of other Curves upon any Given Curve; in the volume for the year 1707. 2. A General Method for Rectifying all Roulets upon Right and Circular Baſes, 1708. 3. General Method of determining the Nature of thoſe Curves which cut an Infinity of other Curves given in Poſition, cutting them always in a Conſtant Angle, 1715. 4. Solution of a Problem propoſed by M. de Lagny, 1716. 5. Treatiſe of the Calculus of Finite Differences, 1717. 6. Second Part of the Calculus of Finite Differences, 1723. 7. Second Section of ditto, 1723. 8. Addition to the two foregoing papers, 1724. 9. New Propoſition in Elementary Geometry, 1725. 10. New Solution of a Problem propoſed to the Engliſh Mathematicians, by the late M. Leibnitz, 1725. 11. Method of Summing an Infinity of New Series, which are not ſummable by any other known method, 1727. 12. Treatiſe of the Lines of the Third Order, or the Curves of the Second Kind, 1729. 13. Examination and Reſolution of ſome Queſtions relating to Play, 1730. 14. Method of determining the Chances at Play. 15. Obſervations upon the Conic Sections, 1731. 16. Manner of generating in a Solid Body all the Lines of the Third Order, 1731. 17. Manner of determining the Nature of Roulets formed upon the Convex Surface of a Sphere; and of determining which are Geometric and which are Rectifiable, 1732. 18. Solution of a Problem in Geometry, 1732. 19. The Uſe of Series in reſolving many Problems in the Inverſe Method of Tangents, 1737. 20. Obſervations on the Irreducible Caſe in Cubic Equations, 1738. 21. Obſervations upon Cubic Equations, 1738. 22. On the Triſection of

Nieuwland. an Angle, 1740. 23. On the Irreducible Case in Cubic Equations, 1741. 24. Addition to ditto, 1743. 25. His Last Paper upon the same, 1744. 26. Determination, by Incommensurables and Decimals, the Values of the Sides and Areas of the Series in a Double Progression of Regular Polygons, inscribed in and circumscribed about a Circle, 1747 *.

Hutton's Dictionary.

NIEUWLAND (Peter), professor of mathematics and natural philosophy in the university of Leyden, was born at Diemermeer, a village near Amsterdam, on the 5th of November, 1764. His father, by trade a carpenter, having a great fondness for books, and being tolerably well versed in the mathematics, instructed his son himself till he attained to his eleventh year. Young Nieuwland appears to have displayed strong marks of genius at a very early period. When about the age of three, his mother put into his hand some prints, which had fifty verses at the botom of them by way of explanation. These verses she read aloud, without any intention that her son should learn them; and she was much surprised some time after to hear him repeat the whole from memory, with the utmost correctness, on being only shewn the prints.

Before he was seven years of age he had read more than fifty different books, and in such a manner that he could frequently repeat passages from them both in prose and in verse. When about the age of eight, Mr Aeneæ at Amsterdam, one of the greatest calculators of the age, asked him if he could tell the solid contents of a wooden statue of Mercury which stood upon a piece of clock-work. "Yes (replied young Nieuwland), provided you give me a bit of the same wood of which the statue was made; for I will cut a cubic inch out of it, and then compare it with the statue." Poems which (says his eulogist) display the utmost liveliness of imagination, and which he composed in his tenth year, while walking or amusing himself near his father's house, were received with admiration, and inserted in different poetical collections.

Such an uncommon genius must soon burst through those obstacles which confine it. Bernardus and Jeronimo de Bosch, two of the first and wealthiest men at Amsterdam, became young Nieuwlands benefactors, and contributed very much to call forth his latent talents. He was taken into the house of the former in his eleventh year, and he received daily instruction from the latter for the space of four years. While in this situation he made considerable progress in the Latin and Greek languages, and he studied philosophy and the mathematics under Wyttenbach. In the year 1783 he translated the two dissertations of his celebrated instructors, Wyttenbach and de Bosch, on the opinions which the ancients entertained of the state of the soul after death, which had gained the prize of the Teylerian theological society.

From the month of September 1784 to 1785, Nieuwland resided at Leyden as a student in the university, and afterwards applied with great diligence, at Amsterdam, to natural philosophy and every branch of the mathematics, under the direction of Professor Van Swinden. He had scarcely begun to turn his attention to chemistry, when he made himself master of the theory of the much lamented Lavoisier, and could apply it to every phenomenon. He could read a work through with uncommon quickness, and yet retain in his mind the principal part of its contents. Nieuwland.

Nieuwland's attention was directed to three principal pursuits, which are seldom united; poetry, the pure mathematics, and natural philosophy. In the latter part of his life he added to these also astronomy. Among the poems which he published, his Orion alone has rendered his name immortal in Holland. Of the small essays which he published in his youth, the two following are particularly deserving of notice: 1. A comparative View of the Value of the different Branches of Science; and, 2. The best Means to render general, not learning, but Soundness of Judgment and Good Taste.

One of his great objects was to bring the pure mathematics nearer to perfection, to clear up and connect their different parts, and in particular to apply them to natural philosophy and astronomy. Cornelius Douwes discovered an easy method of determining the latitude of a place at sea, not by the meridian altitude of the sun, but by two observations made at any other period of the day. This method, however, being still imperfect, Nieuwland turned his thoughts towards the improvement of it, and in the beginning of the year 1789 wrote a paper on the subject, which he transmitted to M. de Lalande at Paris, from whom it met with great approbation. In the year 1792, when Nieuwland resided two months at Gotha with Major Von Zach, these two learned men often conversed on this method of finding the latitude, and calculated the result of observations which they had made with a sextant and an artificial horizon. The above paper, enlarged by these observations, was inserted by Major Von Zach with Nieuwland's name in the first Supplement to Bode's Astronomical Almanack, Berlin, 1793.

This, however, was not the only service which Nieuwland endeavoured to render to astronomy. It had been observed by Newton, Euler, De la Place, and others, that the axes of the planets do not stand perpendicular, but inclined, to the plane of their orbits; and Du Sejour, in his analytical treatise on the apparent motion of the heavenly bodies, considers it as highly probable that this phenomenon depends on some *physical* cause; which, however, he does not venture to assign. Nieuwland proceeded farther, and laid down principles, from which he drew this conclusion, that the above phenomenon is intimately connected with the whole system of attraction. On these principles he made calculations, the result of which was exactly equal to the angle of the inclination of the earth's axis to the plane of its orbit. Nieuwland communicated his discovery with much modesty to the celebrated Professor Damen at Leyden, who proposed some objections to it which discouraged Nieuwland, and induced him to revise his calculations with more accuracy. Major Von Zach transmitted the paper which contained them to M. De la Place at Paris, and caused it to be printed also, for the opinion of the learned, in the Supplement to Professor Bode's Astronomical Almanack for the year 1793.

The writer of this article is not acquainted either with the principles which this young astronomer assumed, or with the calculations which he made from them; but if he holds gravitation to be essential to matter, and the inclination of the axes of the planets to be the necessary result of the law of gravitation, he is undoubtedly

doubtedly in an error. The axes of the planets are not all equally inclined, nor does the inclination vary in exact proportion to the ſquares of the diſtances.

Nieuwland's talents and diligence ſoon recommended him to the notice of his country. In his twenty-ſecond year, he was appointed a member of the commiſſion choſen by the College of Admiralty at Amſterdam for determining the longitude and improving marine charts. On this labour he was employed eight years, and undertook alſo to prepare a nautical almanack, and to calculate the neceſſary tables. The mathematical part was in general entruſted to Nieuwland; but he aſſiſted alſo his two colleagues van Swinden and van Keulen, in the departments aſſigned to them, with ſuch aſſiduity, that moſt of the work publiſhed on the longitude, together with the three additional parts, were the fruits of his labour. In the ſecond edition of the explanation of the nautical almanack, he had alſo the principal ſhare; and he was the author, in particular, of the explanation of the equation of time, the method of determining the going of a time-piece, and of calculating the declination of the moon.

Soon after Nieuwland engaged in this employment, it appeared as if his deſtination was about to be changed. In the year 1787, he was choſen by the States of Utrecht to ſucceed Profeſſor Hennert; but on account of certain circumſtances this appointment did not take place. He was, however, invited to Amſterdam by the magiſtrates of that city, to give lectures on mathematics, aſtronomy, and navigation. While in this ſituation, he wrote his uſeful and excellent treatiſe on navigation, the firſt part of which was publiſhed at Amſterdam in 1793, by George Hulſt van Keulen; and it is much to be wiſhed that M. van Swinden would complete this work from the papers bequeathed to him by his deceaſed friend the author.

In aſtronomical purſuits, Nieuwland applied not only to the theoretical, but alſo to the practical part; and in this ſtudy he was encouraged and aſſiſted by Major von Zach, with whom he reſided ſome time in the courſe of the year 1792, and who inſtructed him in the proper uſe of the ſextant. This affectionate friend publiſhed alſo all his obſervations and calculations in the before-mentioned Supplement to Bode's Aſtronomical Almanack.

In the year 1789, Nieuwland was choſen member of a learned ſociety whoſe object was chemical experiments; and ſo apt was his genius for acquiring knowledge, that in a little time he made himſelf completely maſter of the theory of chemiſtry. A proof of this is the treatiſe which he read on the 24th of May 1791, in the ſociety, diſtinguiſhed by the motto of *Felix Meritis*, and which has been printed in the firſt part of the New General Magazine (*Niew Algemeen Magazyn*). At the ſame time he was able to examine the important diſcoveries made by the ſociety, to aſſiſt in preparing an account of them for the preſs, and to publiſh them with ſufficient accuracy in the French language. Three parts of this work appeared under the title of *Recherches Phyſico-chymiques*. The firſt part appeared in 1792, and was afterwards reprinted in the *Journal de Phyſique*. The ſecond was publiſhed in 1793, and the fourth in 1794. Some letters of his on chemiſtry may be found alſo in a periodical work called *The Meſſenger* (*Letterbode*).

This ingenious and diligent man was of great ſervice alſo in the philoſophical department to the above ſociety, *Felix Meritis*, of which he had been choſen a titular member on the 15th of January 1788, and an honorary member on the 15th of March 1791. The papers for which it was indebted to him are as follows:—1. On the Neweſt Diſcoveries in Aſtronomy, and the Progreſs lately made in that Science, 1788. This is an extract from a Latin oration which he intended to deliver at Utrecht when he expected to ſucceed Profeſſor Hennert.—2. On the Figure of the Earth, 1798.—3. On the Courſe of Comets, and the Uncertainty of the Return of the Comet now Expected, 1790.—4. On the Nature of the Mathematics. The principal object of this paper was to illuſtrate the idea, that the mathematics may be conſidered as a beautiful and perfect language.—5. On the Periodical Decreaſe or Increaſe in the Light of Certain Fixed Stars, and Particularly of the Star Algol, 1790.—6. On the Solution of Spherical Trigonometry by Means of a New Inſtrument Invented by Le Guin, 1791. M. le Guin having tranſmitted to the College of Admiralty at Amſterdam an inſtrument which might be uſed with great advantage in trigonometrical operations, and by which, in calculating the longitude, one could deduce the real from the apparent diſtance, the admiralty charged Nieuwland to examine this inſtrument; and he found that it might be of excellent ſervice for the above purpoſe.—7. On the Relative Value or Importance of the Sciences, 1791.—8. On the Syſtem of Lavoiſier, 1792.—9. On the Selenotopographia of Schröder, 1793.—10. On what is Commonly Called Cultivation, Inſtruction, or Enlightening, 1793.

Nieuwland had applied cloſely to the mathematics, aſtronomy, and navigation, for ſix years; during which time he made conſiderable improvements in nautical charts, and filled up his vacant hours with the ſtudy of philoſophy and chemiſtry. In the month of July 1793 he was invited to the univerſity of Leyden, to be profeſſor of philoſophy, aſtronomy, and the higher mathematics, in the room of the celebrated Damen; and the admiralty of Amſterdam requeſted him to continue his nautical reſearches, which he did with great aſſiduity till the period of his death. The only variation which he now made in his ſtudies related to natural philoſophy, for with the mathematics he was already ſufficiently acquainted. He applied therefore to the experimental part, and ſpared no pains nor labour to become perfect in it; which would certainly have been the caſe, had he not been ſnatched from ſcience and his friends at the early age of thirty. He died of an inflammation in his throat, accompanied with a fever, on the 13th of November 1794.

In his external appearance, Nieuwland was not what might be called handſome, nor had he ever been at pains to acquire that eaſe of deportment which diſtinguiſhes thoſe who have frequented polite company. His behaviour and converſation were however agreeable, becauſe he could diſcourſe with facility on ſo many ſubjects, and never wiſhed to appear but under his real character. On the firſt view one might have diſcerned that he was a man of great modeſty and the ſtricteſt morality. His father was a Lutheran, and his mother anabaptiſt; but he himſelf was a member of what is called the reformed church, *i. e.* a Calviniſt, and always ſhewed ed the utmoft refpect for the Supreme Being both by his words and his actions.

NIGER, a large river in Africa, of which many erroneous accounts have been publifhed, and among them that which we have given in the *Encyclopædia Britannica*. By Herodotus, Pliny, Ptolemy, and other ancient authors, it is uniformly faid to flow from *weft* to *eaft*, dividing Africa as the Danube divides Europe; and from the report of the Africans, the firft of thefe authors calls it a large river abounding with crocodiles. In the twelfth century, however, Edrifi defcribes the Niger, which he calls the Nile of the negroes, as running from *eaft* to *weft*, and falling into the Atlantic Ocean; and his account was univerfally adopted by fubfequent writers, till its falfehood was difcovered by the African Affociation. From a number of concurring reports, Major Houghton was led to believe that the courfe of the Niger is from *weft* to *eaft*, according to the moft ancient account; and the truth of thefe reports has been eftablifhed beyond all controverfy by Mr Park, who faw the Niger himfelf, and actually accompanied it for many miles in its majeftic courfe as laid down by Herodotus.

This river rifes in or near the country of MANDING (which fee in this *Supplement*), between the parallels of 10 and 11 degrees of north latitude, and between the 5th and 9th degree of weft longitude, which comprehends a fpace the moft elevated of all this portion of Africa. This is evident from the oppofite courfes of the three great rivers which rife in it. Thefe are the Gambia, which runs to the weft north-weft; the Senegal, which runs to the north-weft; and the Joilba (A), or Niger, running to the eaft north-eaft. The head of the principal branch of the Senegal river is about 80 geographical miles to the weft of that of the Niger; and the head of the Gambia is again about 100 miles weft of the Senegal.

Mr Park traced the Niger to Silla, a confiderable town about 420 miles from its fource; and it was there larger than the Thames at Weftminfter. But 420 miles are but a very fmall part of the courfe of the Niger, which doubtlefs receives many tributary ftreams before it reach Caffiana, 700 miles farther eaftward, where there is every reafon to believe that it was viewed by the ancient Romans. Our traveller collected at Silla what information he could from the Moorifh and Negro traders concerning the further courfe of this majeftic ftream, as well as of the kingdoms through which it runs; and the following notices he believes to be authentic:

Two fhort days journey to the eaftward of Silla, is the town of Jenne, which is fituated on a fmall ifland in the river; and is faid to contain a greater number of inhabitants than Sego itfelf, or any other town in Bambarra. (See SEGO, *Suppl.*) At the diftance of two days more, the river fpreads into a confiderable lake, called *Dibbie* (or the dark lake); concerning the extent of which, all the information which our author could obtain was, that in croffing it, from weft to eaft, the canoes lofe fight of land one whole day. From this lake, the water iffues in many different ftreams, which terminate in two large branches, one whereof flows towards the north-eaft, and the other to the eaft; but thefe branches join at Kabra, which is one day's journey to the fouthward of Tumbuctoo, and is the port or fhipping-place of that city. The tract of land which the two ftreams encircle, is called Jinbala, and is inhabited by negroes; and the whole diftance, by land, from Jenne to Tumbuctoo, is twelve days journey.

From Kabra, at the diftance of eleven days journey, down the ftream, the river paffes to the fouthward of Houffa, which is two days journey diftant from the river. Of the further progrefs of this great river, and its final exit, all the natives with whom Mr Park converfed feemed to be entirely ignorant. Their commercial purfuits feldom induce them to travel further than the cities of Tombuctoo and Houffa; and as the fole object of thofe journeys is the acquirement of wealth, they pay but little attention to the courfe of rivers, or the geography of countries. It is, however, highly probable that the Nigre affords a fafe and eafy communication between very remote nations. All our author's informants agreed, that many of the negro merchants who arrive at Tumbuctoo and Houffa, from the eaftward, fpeak a different language from that of Bambara, or any other kingdom with which they are acquainted. But even thefe merchants, it would feem, are ignorant of the termination of the river; for fuch of them as can fpeak Arabic, defcribe the amazing length of its courfe in very general terms, faying only, that they believe *it runs to the world's end*.

Major Rennel, by comparing a great many accounts of the progrefs of this river beyond Houffa, with the idea which prevails in that city of its termination, has fhewn it to be in a very high degree probable, that the waters of the Niger have no direct communication with the fea, but that they are fpread out into a great lake in Wangara and Ghana, and evaporated by the heat of the fun. See WANGARA in this *Supplement*.

NILE, the name of a celebrated river, which, as it has been defcribed in the *Encyclopædia*, fhould not have been introduced into this place, did we not think ourfelves bound candidly to confefs that, in our opinion, its fources, at leaft thofe fources which were the objects of ancient curiofity, have never yet been feen by any European. This feems to be proved, beyond the poffibility of controverfy, by Major Rennel in the Appendix to Mr Park's Travels, and by Mr Browne in his account of the *Bahr-el-abiad*, and *Dar-Fur* or *Soudan*. See SOUDAN in this *Supplement*.

Mr Bruce himfelf acknowledges that the Nile, which waters Egypt, is the confluence of two ftreams, and that the weftern ftream, which he, with others, calls *Bahr-el abiad*, or the *white river*, is the largeft of the two. Were a man therefore to travel from Cairo up the banks of the Nile in queft of its fource, he would, doubtlefs, when he fhould arrive at the divifion of the river into two channels, continue his journey up the greater of thefe; for what could induce him to turn afide with the lefs? Not the *name*; for neither the lefs nor the greater has by itfelf the name which, in Egypt, is given to both when united. The former, which undoubtedly has its fource in Abyffinia, is there called the Abay or Abavi; and, in other countries through which

(A) This is the negro name of the river, and fignifies the *great water*.

which it runs, the Bahr el-Afrek; the latter is, from its source to its junction with the Abay, called the Bahr-el-abiad. Pliny believed that the Nile came from the west; and Ptolemy says expressly that its remote source is in the *mountains of the moon*. But this Nile must be the White River, which certainly rises to the westward of Abyssinia, and, according to Abulfeda, in the mountains of Komri or Kummeri; which, in Arabic, signifies *lunar*, being the adjective of Kummer, the moon.

In perfect conformity with this ancient account of the source of the Nile, Mr Ledyard was told at Cairo by certain persons from Dar-Fur, that this celebrated river has its co; fountains in their country, at the distance of 55 days journey to the westward of Senaar, which brings them to the Komri mountains of Abulfeda, who, as well as Ptolemy and Edrisi, places the head of the Nile in a quarter far removed from Abyssinia. Ptolemy has indeed mentioned both branches; and while he describes the eastern in such a way as that it cannot be taken for any other than the Abyssinian branch, or the Nile of Bruce and the Portuguese Jesuits, speaks of a larger branch flowing from a more distant source, situated to the south-west. But this can be no other than Bruce's white river, the *Bahr-el-abiad* of Ledyard and Browne. It is true, there is an apparent difference in the account given by these two last mentioned travellers of the country in which the Bahr-el-abiad rises; but it is a difference only apparent. Ledyard was told at Cairo that it rises in Dar-Fur; Mr Browne, who resided long in Dar-Fur, was there told, that the sources of the river are near to a place called *Donga*, the residence of the chief or king of an idolatrous nation to the southward of Dar-Fur. It is to be observed, however, that the slave-merchants who trade between Donga and Cairo are always attached to the Soudan or Dar-Fur caravan; and that therefore the persons who told Ledyard that the Nile rises in their country were probably from Donga, though he took them for Furians from the name of their caravan. Mr Browne informs us that the country about Donga is very mountainous, and that in the spot where the river rises there are said to be forty distinct hills, which are called *Kumri*. From them issues a great number of springs, that, uniting into one great channel, form the Bahr-el-abiad, which suffers the same periodical increase and diminution as the Nile in Egypt. The people of Donga are quite naked, black, and, as we have already observed, idolaters. Major Rennel places the mountains of the moon between 5° 40′ and 8° 10′ N. Lat. and between 24° 30′ and 30° 25′ E. Long. Their latitude and longitude, as laid down by Mr Browne, are somewhat, tho' very little, different; whilst Geesh, the source of Bruce's Nile, lies between the 10th and 11th degree of N. Lat. and in about the 37th degree of E. Long.

NIMIQUAS, a nation, or, more properly, two tribes in South Africa, called by Vaillant the *Less* and *Greater* Nimiquas.

The country of the Less Nimiquas extends in longitude from the mountains of Camis to the sea on the west, *i. e.* from 15° 25′ to 18° 25′ east from London, and in latude from 28° 12′ to 29° 36′ south. From the information which our author could collect, he thinks that the number of inhabitants throughout the whole of this tract does not exceed 6000 souls. Even this number is annually diminished by the frequent attacks of Boshmen, and the aridity of the soil. Of the BOSHMEN we have already given such an account as can leave no doubt of the destructive nature of their incursions; and the soil must be arid indeed, if it be true, as Vaillant assures us, that in the country of the Less Nimiquas rain never falls except when it thunders, and that thunder is so rare as frequently not to be heard for the space of a whole year.

For this want of rain our author accounts in a satisfactory manner: "The country (he says) having neither forests nor lofty mountains to arrest the clouds, those which come from the north pass freely over it, and proceed on to Camis, where they burst and fall, either in rain in the valleys, or in snow on the summits of these mountains, which are the loftiest throughout the south of Africa." The country is of course not fruitful, and its sterility obliges the inhabitants frequently to change their residence, so that they are the most wandering of all the Hottentot tribes. In this barren region the Dutch colonists suppose that gold mines may be found; but our author discovered among the hordes no traces of this metal, though he found many indications of rich copper mines.

The Less Nimiquas, though of a tolerable stature, are not so tall as their neighbours to the eastward; and indeed Vaillant affirms, that the people to the east in the southern part of Africa are much superior to those of the west both in moral and physical qualities, while the animals are far inferior. The Less Nimiquas are great believers in witchcraft; and our author gives a ridiculous account of an interview that he had with an old witch named *Kakoes*, who had a complete ascendency, not only over the whole horde, but also over the savage Boshmen. These robbers, he says, never attempted to plunder the territory where she took up her residence; and she has been known, when their thefts came to her knowledge, to proceed alone, and unguarded, to their retreats in the midst of the woods, to threaten them with her vengeance, and thus compel them to a restitution of the stolen property. All her influence, however, over her own tribe, could procure for our author and his attendants only six sheep.

The women of the horde received his Hottentots with great kindness; and petmitted them to discover very singular charms, of which it is needless here to insert a description. Among this people he saw abundance of bracelets, necklaces, and ear-rings of copper; and some of these ornaments were so well made and finely polished, that they must have been manufactured in Europe, and the fruits of an intercourse with the whites. But he saw several others, which, from their grotesque shape and rude workmanship, evidently shewed that they were fabricated by the savages themselves.

"These ornaments (says he) are worn by the Nimiquas in the same manner as by the other savages; yet I observed among them some whimsical peculiarities. I have seen persons with six ear-rings of the same shape in one ear, and none in the other: I have seen some with bracelets from the wrist to the elbow on one arm, while the other arm was bare: I have seen others with one side of the face painted in compartments of various colours, while on the other side both the colours and figures were different. In general, I observed great propensity to ornaments among the Less Nimiquas; for

Nimiquas. for their kroffes and all their garments were plentifully covered with glafs and copper beads, ftrung on threads, and faftened on every part of their drefs. They even wore them in their hair, which was plaftered with greafe in the moft difgufting manner. Many had their heads covered with a reddifh incruftation, compofed of greafe and a powder refembling brick-duft, with which their hair was fo pafted together, that you would have fworn it to be a cap of red mortar. Thofe who had it in their power to difplay this luxury of drefs, were as proud as are our *petits-maitres*, when they can fhake a head loaded with powder, perfume, and pomatum. The *nuyp-kros*, or fhort apron, of the women, was adorned with rows of glafs-beads hanging down to their feet; in other refpects they were dreffed like the other Hottentots."

The country of the *Greater Nimiquas* is placed by the author in nearly the fame longitude with that of the Lefs, and between 25° and 28° fouth latitude. It is barren like the other; but the people are much taller, being generally about five feet ten inches high. The men are dull and ftupid, but the women are lively and extremely amorous; and both men and women are comparatively handfome and of a flender make. Extravagantly addicted to fmoking tobacco, the youg girls bartered their favours for a fingle pipe; and as Vaillant was chief of the caravan, a white, and poffeffor of tobacco of much better quality, many advances were made to him. "I have no doubt (fays he) but I might have formed, for a few pipefuls only, an alliance with every family in the horde. I was even preffed fo clofely, as to be obliged to employ fome refiftance: but, at the fame time, I muft confefs, that my refufals were given in fuch a way as not to offend; and they who, in confequence of their advances, had been expofed to them, having foon found other arrangements to make, did not fhew me the lefs friendfhip. I muft here add, that the girls alone appeared to me thus free; while the married women on the contrary were modeft and referved. This is a characteriftic difference, which diftinguifhes the Greater Nimiquas from the Hottentot people in general; as likewife does the low cringing air they affume when they have any thing to afk."

It has been faid by Kolben, that the Nimiqua women, when they bear twins, deftroy one of the infants; but Vaillant affures us that this is a falfehood, as is likewife another tale which is current in the colony. It has been faid that the fathers, to fhow what affection they bear their children, feed their eldeft in a particular manner, as being of right the firft object of paternal care. For this purpofe they put him in a coop as it were; that is, they fhut him up in a trench made under their hut, where, being deprived of motion, he lofes little by perfpiration, while they feed and cram him in a manner with milk and greafe. By degrees the child fattens and gets as round as a barrel; and when he is come to fuch a ftate as not to be able to walk, but to bend under his own weight, the parents exhibit him to the admiration of the horde; who from that period conceive more or lefs efteem and confideration for the family, according as the monfter has acquired more or lefs rotundity.

Such was the account given to our author by a man who affirmed that he had been an eye-witnefs of this mode of cramming the heir-apparent; but whenever any queftions were afked on the fubject of the Nimiquas themfelves, the perfons addreffed were ready to laugh in our author's face. "Still (fays he), as it appeared ftrange to me, that a man fhould talk of what he had feen, when he had in reality feen nothing; as it was poffible that the fable might have fome foundation, without being true in all particulars—I was willing to convince myfelf what could have given rife to it; and every time I vifited a horde, I took care, under different pretences, to examine, one after another, all the huts of the kraal, and to afk which was the eldeft child of the family: but I nowhere faw any thing that indicated either this pretended coop, or this pretended cramming."

Nimiquas ‖ Nizolius.

The Nimiquas are great cowards; yet, like the furrounding nations, they have their affagays and poifoned arrows; and, like them, can handle thefe arms with dexterity. They poffefs alfo thofe war oxen, fo formidable in battle, and fo favourable to the cowardice or inactivity of the combatants. They have even a peculiar implement of war, which their neighbours have not. This is a large buckler, of the height of the perfon who bears it, behind which the Nimiqua can completely conceal himfelf. But, befide that his natural apathy prevents him from giving or taking offence, he is in reality pufillanimous and cowardly from the coldnefs of his difpofition. To utter only the name of *Houzouana* before him is fufficient to make him tremble. See HOUZOUANAS in this *Suppl.*

Notwithftanding his frigidity, the Nimiqua is not infenfible to pleafure. He even feeks with avidity thofe which, acquiring but little exertion, are capable of agitating him and procuring agreeable fenfations. Their mufical inftruments are the fame as thofe of the other Hottentots; but their dancing is very different, and refembles the temper of the nation. If the countenance have received from nature features that can exprefs our paffions, the body alfo has its attitudes and movements that paint our temper and feelings. The dance of the Nimiqua is frigid like himfelf, and fo devoid of grace and hilarity, that, were it not for the extreme gaiety of the women, it might be called the dance of the dead.

Thefe tortoifes, to whom dancing is a fatigue, fhew little eagernefs for any thing but wagers; games of calculation and chance, and all the fedentary amufements which require patience and reflection, of which they are more capable than they are of motion. When our author, with great propriety, prohibited gaming in his camp, the Nimiquas, who had ftaid long with him, took their departure.

NITTA, a fpecies of the MIMOSA, which flourifhes on the banks of the Senegal in Africa. It is valuable to the inhabitants for its fruit, the pods of which are long and narrow, containing a few black feeds enveloped in a fine mealy powder, of a bright yellow colour, which refembles the flour of fulphur, and has a fweet mucilaginous tafte. When eaten by itfelf it is clammy; but when mixed with milk or water, it conftitutes a very pleafant and nourifhing food, fupplying the place of corn to the negroes.—*Park's Travels.*

NIZOLIUS (Marius), a grammarian of Italy, who by his wit and erudition contributed much to the promotion of letters in the 16th century. He publifhed, in 1553, *Lib.* 4. *De veris Principiis et vera Ratione philofo-*

philosophandi, contra Pseudo philosophos. In this work he attacks, with much vivacity, the schoolmen, not only for the barbarism of their terms, but for many ridiculous opinions which they held. Leibnitz was so struck with its solidity and elegance, that, to expose the obstinacy of those who were zealously attached to Aristotle, he gave a new edition of it, with critical notes of his own, 1670, in 4to. Nizolius published also *Thesaurus Ciceronianus, sive Apparatus Linguæ Latinæ e Scriptis Tullii Ciceronis collectus*, in folio. This is a good Latin dictionary, composed of the words and expressions of Cicero; to which, it seems, Nizolius shewed as much bigotry as the schoolmen to their notions; and fell under the character of those pedants whom Erasmus has ridiculed in his *Ciceronianus*. We do not find the year either of his birth or death.

Biog. Dictionary.

NOCTURNAL ARCH, is the arch of a circle described by the sun, or a star, in the night.

NONAGESIMAL, or NONAGESIMAL *Degree*, called also the *Mid heaven*, is the highest point, or 90th degree of the ecliptic, reckoned from its intersection with the horizon at any time; and its altitude is equal to the angle that the ecliptic makes with the horizon at their intersection, or equal to the distance of the zenith from the pole of the ecliptic. It is much used in the calculation of solar eclipses.

NONAGON, a figure having nine sides and angles. In a regular nonagon, or that whose angles and sides are all equal, if each side be 1, its area will be 6.1818242 $= \frac{9}{4}$ of the tangent of 70°, to the radius 1.

NORMAL, is used sometimes for a perpendicular.

NUEL, or NEWEL, the upright post about which stairs turn, being that part of the staircase which sustains one end of the steps.

O.

OASIS (plur. OASES), a fertile spot in the midst of a sandy desart. In the SAHARA, or Great Desart of Africa, there are many *Oases* of exreme fertility.

OBLATE, flatted or shortened; as an oblate spheroid, having its axis shorter than its middle diameter; being formed by the rotation of an ellipse about the shorter axis.

OBLIQUE ASCENSION, is that point of the equinoctial which rises with the centre of the sun, or star, or any other point of the heavens, in an oblique sphere.

OBLIQUE *Circle*, in the stereographic projection, is any circle that is oblique to the plane of projection.

OBLIQUE *Descension*, that point of the equinoctial which sets with the centre of the sun, or star, or other point of the heavens, in an oblique sphere.

OBLIQUE *Force*, or *Percussion*, or *Power*, or *Stroke*, is that made in a direction oblique to a body or plane. It is demonstrated, that the effect of such oblique force, &c. upon the body, is to an equal perpendicular one, as the sine of the angle of incidence is to radius.

OBLONG SPHEROID, is that which is formed by an ellipse revolved about its longer or transverse axis; in contradiction from the *oblate spheroid*, or that which is flatted at its poles, being generated by the revolution of the ellipse about its conjugate or shorter axis.

OBSERVATORY, PORTABLE. See ASTRONOMY, n° 504, *Encycl.*

OCCIDENT EQUINOCTIAL, that point of the horizon where the sun sets, when he crosses the equinoctial, or enters the sign Aries or Libra.

OCCIDENT *Estival*, that point of the horizon where the sun sets at his entrance into the sign Cancer, or in our summer when the days are longest.

OCCIDENT *Hybernal*, that point of the horizon where the sun sets at midwinter, when entering the sign Capricorn.

OCTANT, the eighth part of a circle.

ODD, in arithmetic, is said of a number that is not even. The series of odd numbers is 1, 3, 5, 7, &c.

ODDLY-ODD. A number is said to be oddly-odd, when an odd number measures it by an odd number. So 15 is a number oddly-odd, because the odd number 3 measures it by the odd number 5.

ODOUR, that quality of certain bodies which excites the sensation of smell. In the *Annales de Chimie*, Vol. XXI. p. 254, we have a detailed account of certain experiments made by M. Benedict Prevost of Geneva, with a view to render the *emanations of odorant bodies perceptible to sight*. The account is by much too long for a work like ours; especially as we feel not ourselves inclined to attribute to the experiments all the importance which seems to have been allowed to them by the first class of the French National Institute. We shall therefore state only a few of them, which seem most to favour the author's hypothesis.

1. A concrete odorant substance, laid upon a wet glass or broad saucer covered with a thin stratum of water, immediately causes the water to recede, so as to form a space of several inches around it.

2. Fragments of concrete odorant matter, or small morsels of paper or cork, impregnated with an odorant liquor, and wiped, being placed on the surface of water, are immediately moved by a very swift rotation. Romieu had made this observation on camphor, and erroneously attributed the effect to electricity. The motion was perceptible even in pieces of camphor of seven or eight gros.

3. An odorant liquor being poured on the water, stops the motion till it is dissipated by evaporation. Fixed oil arrests the motion for a much longer time,

Odour.

and until the pellicle it forms on the water is taken off.

4. When the furface of the water is cleaned by a leaf of metal, of paper, or of glafs, plunged in and withdrawn fucceffively until the pellicle is removed, the gyratory motion is renewed. If a piece of red wax or of taper be dipped in water, and the drops fhaken off into a glafs of water containing odorant bodies in motion, the movement will be ftopped. The fame effect is not produced by metal.

5. A morfel of camphor, plunged to the depth of three or four lines in water without floating, excites a movement of trepidation in the furrounding water, which repels fmall bodies in its vicinity, and carries them again to the camphor by ftarts. The author concludes, that an elaftic fluid efcapes from the odorant body in the manner of the fire of a fufee or the difcharge of fire-arms.

6. When there is a certain proportion between the height of the water and that of the fmall fragment of camphor, the water is brifkly driven off, returns again to the camphor, and again retires, as if by an explofion, the recoil of which often caufes the camphor to make part of a revolution on its axis.

7. Camphor evaporates thirty or forty times more fpeedily when placed upon water, than when entirely furrounded with air.

8. Camphor, during the act of diffipation in the air, preferves its form and its opaque whitenefs; upon water it is rounded, and becomes tranfparent as if it had undergone a kind of fufion. It may be inferred, that this arifes from the acquired motion, which caufes it to prefent a greater furface to the air.

9. When fmall pieces of camphor are plunged in water, the camphor becomes rounded and tranfparent, does not acquire any motion, and its diffipation is lefs perceptible than in the air. The concurrence of air and water is therefore neceffary to difengage the fluid which is the caufe of the motion and total diffipation of odorant bodies.

10. The motion of odorant bodies upon water decays and ceafes fpontaneoufly at the end of a certain time; becaufe the water having then contracted a ftrong fmell, the volatilization takes place in all the points of its furface; and the fmall mafs being thus furrounded by the odorant fluid, which is no longer air, diffolves, as in the ordinary odorant fluids, without forming the gafeous jet which is the caufe of the motion. The author compares the volatilization of the aromatic fubftance to a combuftion excited by water.

M. Prevoft hopes, that thefe, and other experiments which he explains, will contribute to the theory of odours, which fo nearly refembles that of the gafes. He does not flatter himfelf with having exhaufted this fubject, but confiders his difcoveries as the means of rendering odour perceptible by water, not only to the fight, but even to the touch, as are likewife the vibrations of fonorous bodies. Men deprived of the fenfe of fmell, and even the blind, according to him, may in this manner diftinguifh odorant bodies from thofe which have no fmell. "Perhaps (fays he) this kind of odorofcope may, by improvement, become an odorimeter. The exceptions, fuch for example as that of the cerumen of the ears, which produces much effect on water without being perceptibly odorant, and that of the fingers when hot or moift, are merely apparent; for if our fenfes do not in thofe cafes difcover odour, thofe of animals more powerfully energetic, fuch as the dog, perceive and diftinguifh individuals by its peculiar character. The odorofcope may afford the information which is wanting refpecting thefe effluvia. Thus it is that the fat of game, the fmell of which is nearly to us imperceptible, is very much fo to dogs, and exhibits fenfible marks by the odorofcope."

Profeffor Venturi of Modena, who heard Prevoft's memoir read in the National Inftitute, had himfelf made fome experiments with camphor kept feparately in the air, in the water, and at the furface of the water; whence he deduces, that the moft active virtue for diffolving camphor refides at that part where both the air and the water touch the camphor at the fame time. Hence he explains why, in like circumftances, camphor evaporates more quickly in a moift than in a dry air; and why the Hollanders ufe water in their procefs for fubliming this fubftance.

It might be thought that the camphor was decompofed at the furface of the water; that the water might feize the acidifying part, which renders the camphor concrete; and that the volatile part is diffipated in the atmofphere. The author rejects this notion. He thinks that water with camphor floating on its furface becomes charged with no more than a very fmall portion: 1. Becaufe in thefe circumftances the water acquires the fame tafte and fmell of camphor as it obtains when a fmall quantity of this fubftance is kept plunged in the fame fluid. This water, by expofure to the air, lofes the qualities with which it had been charged, and becomes infipid, and without fmell. 2. Becaufe when the water is faturated with all it can take up, the diffipation of the camphor continues at its furface as before. 3. Becaufe the aerial emanations of camphor made at the furface of water do themfelves cryftallize into camphor.

Camphor at the furface of the water does nothing, therefore, but diffolve; and when diffolved at the ordinary temperature of the atmofphere, it is not at firft in the ftate of vapour as has been thought. It is fimply a liquid which extends itfelf over the furface of water itfelf; and by this means coming into contact with a great furface of air, it is afterwards abforbed and evaporated. This is proved by the following facts: 1 The folution of camphor at the furface of water is more rapid in proportion to the extent of the furface. In narrow veffels, the fection of the column would not be completed in ten days, even though the water might be extremely pure. 2. When the column of camphor has projecting parts, the liquid may be feen iffuing by preference from certain points of the column, covering the furface of the water, and driving fmall floating bodies before it, in the fame manner as floating bodies go and return in a bafon into which the water of a canal enters with rapidity. 3. If a fmall piece of camphor, already wetted at one end, be brought near the edge of water contained in a broad faucer, and be made to touch the faucer itfelf, it depofits a vifible liquor, which is oily; and by attaching itfelf to the faucer, deftroys the adhefion between the veffel and the border of the water, fo that the water retires on account of the affinity of aggregation, which not being oppofed by the attraction of the faucer, caufes the water to terminate in a round edge.

edge. If you remove the piece of camphor, the water will not return to its place until the oily fluid is evaporated. 4. In the same manner, when the column of camphor is half immersed in the water, the oily liquor which issues forth destroys the adhesion of the water to the column, and produces a small surrounding cavity. The solution stops, or is retarded for a moment, until the fluid, extending itself over the water, becomes evaporated: the water then returns to its place, and touches the same part of the camphor; the solution begins again, and in this manner the process is effected by alternations of contact and apparent repulsion.

Of these memoirs by Prevost and Venturi, the English reader will find accurate and full translations in the first volume of *Nicholson's Philosophical Journal*, together with some judicious observations on them by the editor, which we shall take the liberty to adopt. "The philosophical consideration of odorant bodies is somewhat obscured by the old method of generalizing, or referring the properties of bodies to some distinct principle or thing supposed capable of being separated from the body itself. Thus the odours of bodies have been supposed to depend on a substance imagined in a loose way to be common to them all and separable from them. Hence the terms, principle of smell, spiritus rector, and even in the modern nomenclature we find *aroma*. There does not in effect seem to be any more reason to infer the existence of a common principle of smell than of taste. The smell of ammoniac is the action of that gas upon the organ of sense; and this odorant invisible matter is exhibited to the sight when combined with an acid gas. But in the same manner as ammoniac emanates from water, and leaves most part of that fluid behind, so will the volatile parts of bodies be most eminently productive of this action; and very few, if any, natural bodies will be found which rise totally. The most striking circumstance in the effect is, that an act of such power should be attended with a loss by exhalation which is scarcely to be appreciated by weight, or in any other method during a short interval of time. But we know so little of nervous action, and of other phenomena of electricity, of galvanism (See Galvanism in this *Suppl.*), or even of heat, which strongly affect the senses, but elude admeasurement by gravitation, that the difficulty of weighing the effluvia of odorant bodies becomes less astonishing."

ŒCONOMISTS, a sect of philosophers in France, who have made a great noise in Europe, and are generally believed to have been unfriendly to religion. The founder of this sect was a *Dr Duquesnai*, who had so well insinuated himself into the favour of Louis XV. that the king used to call him his *thinker*. The sect was called *œconomists*, because the œconomy and order to be introduced into the finances, and other means of alleviating the distresses of the people, were perpetually in their mouths. The Abbé Barruel admits, that there may have been some few of them who directed their speculations to no other object; but he brings very sufficient proof that the great aim of the majority of the sect was to eradicate from the minds of the people all reverence for divine revelation.

"Duquesnai (says he) and his adepts had more especially undertaken to persuade their readers, that the country people, and mechanics in towns, were entirely destitute of that kind of instruction necessary for their professions; that men of this class, unable to acquire knowledge by reading, pined away in an ignorance equally fatal to themselves and to the state; that it was necessary to establish free schools, and particularly throughout the country, where children might be brought up to different trades, and instructed in the principles of agriculture. D'Alembert, and the Voltairean adepts, soon perceived the advantages they could reap from these establishments. In union with the œconomists, they presented various memorials to Louis XV. in which not only the temporal but even the spiritual advantages of such establishments for the people are strongly urged. The king, who really loved the people, embraced the project with warmth. He opened his mind on the subject to Mr Bertin, whom he honoured with his confidence, and had entrusted with his privy purse;" and it was with great difficulty that this minister could convince him of the dangerous designs of the sect.

"Determined (says he) to give the king positive proof that the œconomists imposed upon him, I sought to gain the confidence of those pedlars who travel through the country, and expose their goods to sale in the villages, and at the gates of country seats. I suspected those in particular who dealt in books to be nothing less than the agents of philosophism with the good country folks. In my excursions into the country I fixed my attention above all on the latter. When they offered me a book to buy, I questioned them what might be the books they had? Probably catechisms or prayer-books? Few others are read in the villages? At these words I have seen many smile. No, they answered, those are not our works; we make much more money of Voltaire, Diderot, and other philosophic writings. What! said I; the country people buy Voltaire and Diderot? Where do they find the money for such dear works? Their constant answer was, we have them at a much cheaper rate than prayer-books; we can sell them at ten sols (5d.) a volume, and have a pretty profit into the bargain. Questioning some of them still farther, many of them owned that those books cost them nothing; that they received whole bales of them without knowing whence they came, but being simply desired to sell them in their journeys at the lowest price.

"Louis XV. warned by the discovery made by his minister, was at length satisfied that the establishment of these schools, so much urged by the conspirators, would only be a new instrument of seduction in their hands. He abandoned the plan; but, perpetually harassed by the protecting sophisters, he did not strike at the root of the evil, and but feebly impeded its progress. The pedlars continued to promote the measures of the conspirators; yet this was but one of the inferior means employed to supply the want of their free schools, as a new discovery brought to light one far more fatal.

"About the middle of the month of September 1789, little more than a fortnight antecedent to the atrocious 5th and 6th of October, at a time when the conduct of the National Assembly, having thrown the people into all the horrors of a revolution, indicated that they would set no bounds to their pretensions, Mr Le Roy, lieutenant of the King's hunt, and an academician, being at dinner at the house of Mr D'Angevilliers, intendant of the buildings of his majesty, the conver-

Œconomists.

conversation turned on the disasters of the revolution, and on those that were too clearly to be foreseen. Dinner over, the nobleman above-mentioned, a friend of Le Roy, hurt at having seen him so great an admirer of the sophisters, reproached him with it in the following expressive words : *Well! this, then, is the work of Philosophy!* Thunderstruck at these words—Alas ! cried the academician, *to whom do you say so? I know it but too well, and I shall die of grief and remorse!* At the word *remorse*, the same nobleman questioned him whether he had so greatly contributed towards the revolution as to upbraid himself with it in that violent manner? ' Yes (answered he), I have contributed to it, and far more than I was aware of. I was secretary to the committee to which you are indebted for it ; but I call heaven to witness, that I never thought it would go to such lengths. You have seen me in the king's service, and you know that I love his person. I little thought of bringing his subjects to this pitch, *and I shall die of grief and remorse!*'

" Pressed to explain what he meant by this committee, this secret society, entirely new to the whole company, the academician resumed : ' This society was a sort of club that we philosophers had formed among us, and only admitted into it persons on whom we could perfectly rely. Our sittings were regularly held at the Baron D'Holbach's. Lest our object should be surmised, we called ourselves œconomists. We created Voltaire, though absent, our honorary and perpetual president. Our principal members were D'Alembert, Turgot, Condorcet, Diderot, La Harpe, and that Lamoignon, keeper of the seals, who on his dismission shot himself in his park.'

" The whole of this declaration was accompanied with tears and sighs ; when the adept, deeply penitent, continued : ' The following were our occupations; the most of those works which have appeared for this long time past, against religion, morals, and government, were ours, or those of authors devoted to us. They were all composed by the members or by the orders of the society. Before they were sent to the press, they were delivered in at our office. There we revised and corrected them ; added to, or curtailed them, according as circumstances required. When our philosophy was too glaring for the times, or for the object of the work, we brought it to a lower tint ; and when we thought that we might be more daring than the author, we spoke more openly. In a word, we made our writers say exactly what we pleased. Then the work was published under the title or name we had chosen, the better to hide the hand whence it came. Many, supposed to have been posthumous works, such as *Christianity Unmasked*, and divers others *attributed to Freret and Boulanger* after their deaths, were issued from our society.

' When we had approved of those works, we began by printing them on fine or ordinary paper, in sufficient number to pay our expences, and then an immense number on the commonest paper. These latter we sent to hawkers and booksellers free of cost, or nearly so, who were to circulate them among the people at the lowest rate. These were the means used to pervert the people, and bring them to the state you now see them in. I shall not see them long, *for I shall die of grief and remorse!*'

Oil.

This recital is too well authenticated to be called in question, and too plain to need a commentary. Let it be a warning against all secret societies, by whatever title of benevolence they may be designed by those who form them.

OIL-MILL, a mill for expressing the oils from fruits, or grains, &c. As these kingdoms do not produce the olive, it would be needless to describe the mills which are employed in the southern parts of Europe. We shall content ourselves, therefore, with a description of a Dutch oil-mill, employed for grinding and pressing lintseed, rape-seed, and other oleaginous grains. Farther, to accommodate our description still more to our local circumstances, we shall employ water as the first mover ; thus avoiding the enormous expence and complication of a windmill.

In Plate XXXVIII. fig. A,

1. Is the elevation of a wheel, over or undershot, as the situation may require.

2. The bell-metal socket, supported by masonry, for receiving the outer gudgeon of the water-wheel.

3. The water course.

Fig. B.

1. A spur wheel upon the same axis, having 52 teeth.

2. The trundle that is driven by N° 1. and has 78 staves.

3. The *wallower*, or axis for raising the pestles. It is furnished round its circumference with *wipers* for lifting the *pestles*, so that each may fall twice during one turn of the water wheel, that is, three *wipers* for each pestle.

4. A frame of timber, carrying a concave half cylinder of bell-metal, in which the wallower (cased in that part with iron plates) rests and turns round. It will be seen in profile, fig. G.

5. Masonry supporting the inner gudgeon of the water wheel and the above-mentioned frame.

6. Gudgeon of the wallower, which bears against a bell-metal step fixed in the wall. This double support of the wallower is found to be necessary in all mills which drive a number of heavy stampers.

Fig. C, Is the elevation of the pestle and press-frame, their furniture, the mortars, and the press-pestles.

1. The six pestles.

2. Cross pieces between the two rails of the frame, forming, with these rails, guides for the perpendicular motion of the pestles.

3. The two rails. The back one is not seen. They are checked and bolted into the standards N° 12.

4. The tails of the *lifts*, corresponding to the wipers upon the wallower.

5. Another rail in front, for carrying the *detents* which hold up the pestles when not acting. It is marked 14 in fig. M.

6. A beam a little way behind the pestles. To this are fixed the pulleys for the ropes which lift and stop the pestles. It is represented by 16 in fig. M.

7. The said pulleys with their ropes.

8. The *driver*, which strikes the wedge that presses the oil.

9. The *dischaarger*, a stamper which strikes upon the inverted wedge, and loosens the press.

 10.

10. The lower rail with its crofs pieces, forming the lower guides of the peftles.

11. A fmall cog-wheel upon the wallower, for turning the *fpatula*, which ftirs about the oil-feed in the *chauffer-pan*. It has 28 teeth, and is marked N° 6. in fig. M.

12. The four ftandards, mortifed below into the *block*, and above into the joifts and beams of the building.

13. The fix *mortars* hollowed out of the block itfelf, and in fhape pretty much like a kitchen pot.

14. The feet of the peftles, rounded into cylinders, and fhod with a great lump of iron.

15. A board behind the peftles, ftanding on its edge, but inclining a little backwards. There is fuch another in front, but not reprefented here. Thefe form a fort of trough, which prevents the feed from being fcattered about by the fall of the peftles, and loft.

16. The firft *prefs-box* (alfo hollowed out of the block), in which the grain is fqueezed, after it has come for the firft time from below the milftones.

17. The fecond *prefs-box*, at the other end of the block, for fqueezing the grain after it has paffed a fecond time under the peftles.

18. Frame of timber for fupporting the other end of the wallower, in the fame manner as at N° 4. fig. B.

19. Small cog-wheel on the end of the wallower for giving motion to the milftones. It has 28 teeth.

20. Gudgeon of the wallower, bearing on a bell metal focket fixed in the wall.

21. Veffels for receiving the oil from the prefs-boxes.

22. Joifts fupporting the block.

Fig. D. Elevation and mechanifm of the milftones.

1. *Upright fhaft*, carrying the great cog-wheel above, and the *runner milftones* below in their frame.

2. Cog-wheel of 76 cogs, driven by N° 19. of fig. C.

3. The frame of the *runners*. This will be more diftinctly underftood in N° 4. fig. H.

4. The innermoft runner, or the one neareft the fhaft.

5. Outermoft ditto, being farther from the fhaft.

6. The *inner rake*, which collects the grain under the outer runner.

7. The *outer rake*, which collects the grain under the inner runner. In this manner the grain is always turned over and over, and crufhed in every direction. The inner rake lays the grain in a flope, of which fig. O. is a fection; the runner flattens it, and the fecond rake lifts it again, as is marked in fig. P; fo that every fide of a grain is prefented to the milftone, and the reft of the *legger* or *nether milftone* is fo fwept by them, that not a fingle grain is left on any part of it. The outer rake is alfo furnifhed with a rag of cloth, which rubs againft the border or hoop that furrounds the nether milftone, fo as to drag out the few grains which might otherwife remain in the corner.

8. The ends of the iron axle which paffes through the upright fhaft, and through the two runners. Thus they have two motions: 1*mo*, A rotation round their own axis. 2*do*, That by which they are carried round upon the nether milftone on which they roll. The holes in thefe milftones are made a little widifh; and the holes in the ears of the frame, which carry the ends of the iron axis, are made oval up and down. This great freedom of motion is neceffary for the runner milftones, becaufe frequently more or lefs of the grain is below them at a time, and they muft therefore be at liberty to get over it without ftraining, and perhaps breaking, the fhaft.

9. The ears of the frame which lead the two extremities of the iron axis. They are mortifed into the under fide of the bars of the fquare frame that is carried round with the fhaft.

10. The border or hoop which furrounds the nether milftone.

11. and 12. The nether milftone and mafonry which fupports it.

Fig. E. Form of the wallower, fhewing the difpofition of the wipers along its furface.

1. Two parts of this fhaft, which are nicely rounded, and fortified with iron plates, and which reft upon the bell-metal concaves, which are reprefented in n° 4. of fig. C.

2. The little wheels at each end, for giving motion to the two fpatulæ, marked n° 11. fig. C.

3. The wipers for the fecond prefs.

4. The wipers for the firft prefs.

5. The wipers for the fix peftles.

Fig. F. Reprefents the furface of the wallower unfolded into a rectangular parallelogram, in order to fhew the diftribution of the wipers, and confequently the fucceffion of the ftrokes given by the different peftles. This diftribution has fomething peculiar. Each peftle has three wipers; and there are alfo three for the driver and difcharger of the fecond prefs. The driver and wiper of the firft prefs have but one and a half; one for the driver, and the half for the difcharger; fo that it ftrikes twice, and the driver only once, in a turn of the fhaft. This is the Dutch practice, which differs from that of Flanders. The fucceffion of the ftrokes may be conceived as follows: Reckon the ftampers, including thofe of the preffes, from the water-wheel toward the other end of the wallower, and calling them *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, and fuppofing that *a* makes the firft ftroke, they proceed in the following order for one turn of the wallower:

ab, *d*, *f*, *h*, *c*, *e*, *g*, *ab*, *d*, *f*, *h*, *c*, *e*, *g*, *ab*, *d*, *f*, *h*, *c*, *e*, *g*.

Here it may be obferved that *a* and *b* ftrike together. They would do fo if allowed; but one of them is held up by its detent till the workman fees proper to difengage it. Each peftle, and the driver and difcharger of the fecond prefs, makes three ftrokes for one turn of the wallower. But the driver *k* of the firft prefs makes only one ftroke in that time, namely, in the interval between the laft ftrokes of *e* and *g*. The difcharger *i* of this prefs makes two ftrokes; one of them in this fame interval, and the other along with the firft ftroke of *e*. The fecond preffing requires a much more violent preffure than the firft, becaufe the cake muft be left perfectly dry and hard.

Fig. G, Profile of the frame of timber which carries the wallower, and greatly contributes to render its motion fteady.

Fig. H. Is a view of one of the milftones.

1. The nether milftones, and the mafonry fupporting the whole.

2. The runner.

3. A

Oil.

3. A ſort of caſe which encloſes the two wings of the milſtone at a very ſmall diſtance from it, in order to prevent the grain which ſticks to it from being ſcattered. There is another method practiſed at ſome mills.

Fig. I. Repreſents that of Sardamm. AA are two iron rods, about half an inch ſquare, hanging on the axle, on each ſide of the milſtone. Theſe rods are joined by a croſs piece C, which almoſt touches the milſtone. A piece of leather is put between, which rubs upon the milſtone, and clears it of the grain which chances to ſtick to it. N° 4. and 6. repreſent the ears of this frame, by which the end of the iron axle is ſupported, and carried round by the upright ſhaft n° 5.

Fig. K. Plan of the runner milſtones, and the frame which carries them round.

1, 1. Are the two milſtones.

3, 3, 3, 3. The outſide pieces of the frame.

4, 4, 4, 4. The croſs bars of the frame which embrace the upright ſhaft 5, and give motion to the whole.

6, 6. The iron axis upon which the runners turn.

7. The outer rake.

8. The inner ditto.

Fig. L. Repreſents the nether milſtone ſeen from above.

1. The wooden gutter, which ſurrounds the nether milſtone.

2. The border or hoop, about ſix inches high, all round, to prevent any ſeed from being ſcattered.

3. An opening or trap-door in the gutter, which can be opened or ſhut at pleaſure. When open, it allows the bruiſed grain, collected in and ſhoved along the gutter by the rakes, to paſs through into troughs placed below to receive it.

4. Portion of the circle deſcribed by the outer runner.

5. Portion of the circle deſcribed by the inner one. By theſe we ſee that the two ſtones have different routes round the axis, and bruiſe more ſeed.

6. The outer rake.

7. The inner ditto.

8. The ſweep, making part of the inner rake, occaſionally let down for ſweeping off all the ſeed when it has been ſufficiently bruiſed. The preſſure and action of theſe rakes is adjuſted by means of wooden ſprings, which cannot be eaſily and diſtinctly repreſented by any figure. The oblique poſition of the rakes (the outer point going foremoſt) cauſes them to ſhove the grain inwards or toward the centre, and at the ſame time to turn it over, ſomewhat in the ſame manner as the mould-board of a plough ſhoves the earth to the right hand, and partly turns it over. Some mills have but one ſweeper; and indeed there is great variety in the form and conſtruction of this part of the machinery.

Fig. M. Profile of the peſtle frame.

1. Section of the horizontal ſhaft.

2. Three wipers for lifting the peſtles.

3. Little wheel of 28 teeth for giving motion to the ſpatula.

4. Another wheel, which is driven by it, having 20 teeth.

5. Horizontal axle of ditto.

6. Another wheel on the ſame axle, having 13 teeth.

7. A wheel upon the upper end of the ſpindle, having 12 teeth.

8. Two guides, in which the ſpindle turns freely, and ſo that it can be ſhifted higher and lower.

9. A lever, moveable round the piece n° 14. and having a hole in it at 9, through which the ſpindle paſſes, turning freely. The ſpindle has in this place a ſhoulder, which reſts on the border of the hole 9; ſo that by the motion of this lever the ſpindle may be diſengaged from the wheel-work at pleaſure. This motion is given to it by means of the lever 10, 10, moveable round its middle. The workman employed at the chauffer pulls at the rope 10, 11, and thus diſengages the ſpindle and ſpatula.

11. A peſtle ſeen ſidewiſe.

12. The *lift* of ditto.

13. The upper rails, marked n° 3. in fig. C.

14. The rail, marked n° 5. in fig. C. To this are fixed the detents, which ſerve to ſtop and hold up the peſtles.

15. A detent, which is moved by the rope at its outer end.

16. A bracket behind the peſtles, having a pulley, through which paſſes the rope going to the detent 15.

17. The ſaid pulley.

18. The rope at the workman's hand, paſſing through the pulley 17, and fixed to the end of the detent 15.

This detent naturally hangs perpendicular by its own weight. When the workman wants to ſtop a peſtle, he pulls at the rope 18, during the riſe of the peſtle. When this is at its greateſt height, the detent is horizontal, and prevents the peſtle from falling by means of a pin projecting from the ſide of the peſtle, which reſts upon the detent, the detent itſelf being held in that poſition by hitching the loop of the rope upon a pin at the workman's hand.

19. The two lower rails, marked n° 10. fig. C.

20. *Great* wooden, and ſometimes ſtone, *block*, in which the mortars are formed, marked n° 21. in fig. C.

21. Veſſel placed below the preſs boxes for receiving the oil.

22. Chauffer, or little furnace, for warming the bruiſed grain.

23. Backet in the front of the chauffer, tapering downwards, and opening below in a narrow ſlit. The hair bags, in which the grain is to be preſſed after it has been warmed in the chauffer, are filled by placing them in this backet. The grain is lifted out of the chauffer with a ladle, and put into theſe bags; and a good quantity of oil runs from it through the ſlit at the bottom into a veſſel ſet to receive it.

24. The ſpatula attached to the lower end of the ſpindle, and turning round among the grain in the chauffer-pan, and thus preventing it from ſticking to the bottom or ſides, and getting too much heat.

Fig. N, Plan of part of the works.

1, 1. Furnaces for warming the grain.

2, 2. The backets for holding the ſacks while they are a-filling.

3, 3. The pan in which the bruiſed grain is heated by the chauffer.

4, 4. A trough for receiving the chips, into which the preſſed oil-cakes are cut, to be afterwards put into the pan and warmed.

5. The preſs-box for the ſecond preſſing.

6. The preſs-box for the firſt preſſing.

7. The ſix mortars.

8. The ſloping boards, to hinder the ſcattering of the oil ſeed.

9. The

9. The nether milftone, but out of its place.

10. Its centre a little higher than the reft.

11. A rib of wood going round the edge of the nether milftone, and even with its furface, but rifing a very little outwards, and furrounded with a border or hoop about an inch high, to prevent the feed from being fcattered on the ground.

Fig. Q. A fection lengthwife of the great block, with the mortars and prefs-boxes.

1. The fix peftles.

2. The fix mortars, each of which has an iron plate at its bottom.

3. The *driving* ftamper, which falls on the wedge of the firft preffing.

4. Ditto, for the fecond ditto.

5. The *difcharger*, which ftrikes on the inverted wedge in order to free the prefs.

6. Ditto, for the fecond preffing.

7. Wedge for freeing the prefs.

8. Wedge for preffing.

9. Wooden *cheeks*, two inches thick, which are placed between the middle wedge and the *fliding wedges* on each fide.

10. Prefs-irons, between which are placed the hair-bags containing the bruifed grain.

11. Iron plate, called the *fountain*, at the bottom, pierced with holes, correfponding with a hole in the block, for allowing the oil to run off from the preffed grain.

12. Veffel for receiving ditto.

13. A long iron plate at the bottom of the prefs box, under the drawing and difcharging wedges.

Fig. R. Another view of the prefs-irons.

1. The fide-irons laid flat.

2. The fame feen edgewife.

3. The pierced iron plate, upon which the two irons, n° 1. ftand upright, with the hair-bag between them.

4. One of the hair-bags. It may be obferved that the feams of thefe bags are made on the flat fides, and not on the edges, where they would be in danger of burfting.

5. A long hair-cloth, in which the bag is wrapped before it is fet into the prefs. The bag, being filled with bruifed grain, is placed with its bottom at *a*, and the top at *b*; the part *c a* is lapped over it, reaching to *b*, and then the other end *d* is lapped over that, and reaches to *a*, and the loop at its end ferves as a handle by which to lift it, and place it properly between the prefs-irons.

Fig. S. The principal pieces of the prefs.

1. The wooden cheeks.

2. The difcharging wedge.

3. The driving wedge.

4 and 5. The fliding blocks, which tranfmit the preffure produced by the driving wedge.

The foregoing enumeration and views of the different parts of a Dutch oil mill, are fufficient, we imagine, to enable an intelligent mill-wright, to whom the machine is altogether new, to underftand its manner of working, and its adaptation to the various parts of the procefs for extracting the oil from feeds or kernels. It would require a very minute defcription indeed to explain it to a perfon altogether unacquainted with mill-work.

The firft part of the procefs is bruifing the feed under the runner ftones (A). That this may be more expeditioufly done, one of the runners is fet about ⅔ds of its own thicknefs nearer the fhaft than the other. Thus they have different treads; and the grain, which is a little heaped towards the centre, is thus bruifed by both. The inner rake gathers it up under the outer ftone into a ridge, of which the fection is reprefented in Plate XL. fig. O. The ftone paffes over it, and flattens it. It is gathered up again into a ridge, of the form of fig. P. under the inner ftone, by the outer rake, which confifts of two parts. The outer part preffes clofe on the wooden border which furrounds the nether ftone, and fhoves the feed obliquely inwards, while the inner part of this rake gathers up what had fpread toward the centre. The other rake has a joint near the middle of its length, by which the outer half of it can be raifed from the nether ftone, while the inner half continues preffing on it, and thus fcrapes off the moift pafte. When the feed is fufficiently bruifed, the miller lets down the outer end of the rake. This immediately gathers the whole pafte, and fhoves it obliquely outwards to the wooden rim, where it is at laft brought to a part that is left unboarded, and it falls through into troughs placed to receive it. Thefe troughs have holes in the bottom, through which the oil drips all the time of the operation. This part of the oil is directed into a particular ciftern, being confidered as the pureft of the whole, having been obtained, without preffure, by the mere breaking of the hull of the feed.

In fome mills this operation is expedited, and a much greater quantity of this beft oil is obtained, by having the bed of mafonry which fupports the legger formed into a little furnace, and gently heated. But the utmoft care is neceffary to prevent the heat from becoming confiderable. This, enabling the oil to diffolve more of the fermentable fubftance of the feed, expofes the oil to the rifk of growing foon very rancid; and, in general, it is thought a hazardous practice, and the oil does not bring fo high a price.

When the pafte comes from under the ftones, it is put into the hair bags, and fubjected to the firft preffing. The oil thus obtained is alfo efteemed as of the firft quality, fcarcely inferior to the former, and is kept apart. (The great oil ciftern being divided into feveral portions by partitions.)

The oil cakes of this preffing are taken out of the bags, broken to pieces, and put into the mortars for the firft *ftamping*. Here the pafte is again broken down, and the parenchyma of the feed reduced to a fine meal. Thus free egrefs is allowed to the oil from every veficle in which it was contained. But it is now rendered much more clammy, by the forcible mixture of the mucilage,

(A) We are told that, in a mill at Reichenhoffen in Alface, a confiderable improvement has been made by paffing the feed between two fmall iron rollers, before it is put under the milftones. A great deal of work is faid to be faved by this preliminary operation, and finer oil produced, which we think very probable. The ftamping and preffing go on as in other mills.

cilage, and even of the finer parts of the meal. When sufficiently pounded, the workman ftops the peftle of a mortar, when at the top of its lift, and carries the contents of the mortar to the firft chauffer pan, where it is heated to about the temperature of melting bees wax (this, we are told, is the teft), and all the while ftirred about by the fpatula. From thence it is again put into hair bags, in the manner already defcribed; and the oil which drips from it during this operation is confidered as the beft of the fecond quality, and in fome mills is kept apart. The pafte is now fubjected to the fecond preffing, and the oil is that of the fecond quality.

All this operation of pounding and heating is performed by one workman, who has conftant employment by taking the four mortars in fucceffion. The putting into the bags and conducting of the preffing gives equal employment to another workman.

In the mills of Piccardy, Alface, and moft of Flanders, the operation ends here; and the produce from the chauffer is increafed, by putting a fpoonful or two of water into the pan among the pafte.

But the Dutch take more pains. They add no water to the pafte of this their *firft ftamping*. They fay that this greatly lowers the quality of the oil. The cakes which refult from this preffing, and are there fold as food for cattle, are ftill fat and foftifh. The Dutch break them down, and fubject them to the peftles for the *fecond ftamping*. Thefe reduce them to an impalpable pafte, ftiff like clay. It is lifted out, and put into the *fecond* chauffer pan; a few fpoonfuls of water are added, and the whole kept for fome time as hot as boiling water, and carefully ftirred all the while. From thence it is lifted into the hair bags of the laft prefs, fubjected to the prefs; and a quantity of oil, of the loweft quality, is obtained, fufficient for giving a fatisfactory profit to the miller. The cake is now perfectly dry, and hard, like a piece of board, and is fold to the farmers. Nay, there are fmall mills in Holland, which have no other employment than extracting the oil from the cakes which they purchafe from the French and Brabanters; a clear indication of the fuperiority of the Dutch practice.

The nicety with which that induftrious people conduct all their bufinefs is remarkable in this manufacture.

In their oil ciftern, the parenchymous part, which unavoidably gets through, in fome degree, in every operation, gradually fubfides, and the liquor, in any divifion of the ciftern, comes to confift of ftrata of different degrees of purity. The pumps which lift it out of each divifion are in pairs; one takes it up from the very bottom, and the other only from half depth. The laft only is barrelled up for the market, and the other goes into a deep and narrow ciftern, where the dreg again fubfides, and more pure oil of that quality is obtained. By fuch careful and judicious practices, the Dutch not only fupply themfelves with this important article, but annually fend confiderable quantities into the very provinces of France and Flanders where they bought the feed from which it was extracted. When we reflect on the high price of labour in Holland, on the want of timber for machinery, on the expence of building in that country, and on the enormous expence of wind mill machinery, both in the firft erection and the fubfequent wear and tear, it muft be evident, that oil mills erected in England on water falls, and after the Dutch manner, cannot fail of being a great national advantage. The chatellanie or feigneurie of Lille alone makes annually between 30,000 and 40,000 barrels, each containing about 26 gallons.

What is here delivered is only a fketch. Every perfon acquainted with machinery will underftand the general movements and operations. But the intelligent mechanic well knows, that operations of this kind have many minute circumftances which cannot be defcribed, and which, neverthelefs, may have a great influence on the whole. The rakes in the bruifing-mill have an office to perform which refembles that of the hand, directed by a careful eye and unceafing attention. Words cannot communicate a clear notion of this; and a mill, conftructed from the beft drawings, by the moft fkilful workman, may gather the feed fo ill, that the half of it fhall not be bruifed after many rounds of the machinery. This produces a fcanty return of the fineft oil; and the mill gets a bad character. The proprietor lofes his money, is difcouraged, and gives up the work.—There is no fecurity but by procuring a Dutch millwright, and paying him with the liberality of Britons. Such unhoped-for talks have been performed of late years by machinery; and mechanical knowledge and *invention* is now fo generally diffufed, that it is highly probable that we fhould foon excel our teachers in this branch. But this very diffufion of knowledge, by encouraging fpeculation among the artifts, makes it a ftill greater rifk to erect a Dutch oil mill without having a Dutchman, acquainted with its moft improved prefent form, to conduct the work. We do our duty in giving this counfel.

OKU-JESSO. See SEGALIEN in this *Suppl.*

OMPHALOPTER, or OMPHALOPTIC, in optics, a glafs that is convex on both fides, popularly called a *convex lens*.

ONISCUS. See *Encycl.*—Two new fpecies of this genus of infects were difcovered by *La Martiniere*, the naturalift who accompanied Peroufe on his laft voyage of difcovery. For the information of fuch of our readers as are entomologifts, we fhall give the author's defcription of thefe fpecies. Of the firft, which he fays only *nearly* anfwers to the *generic* character of onifcus, E (fig. 1.) is a view of the upper part of its body, and at F of the lower. Its body is cruftaceous, and of an opaque white, with two round ruft-coloured fpots on the anterior part of its corflet; two others, much larger, in the form of a crefcent, are on the *clytræ*; its fhield is alfo of the fame colour. The under part of the thorax is furnifhed with four pair of legs: the firft and third of which are terminated with fharp claws; the fecond, from its form, ferves it to fwim with; the fourth is very fmall, confifting of two membranaceous threads. Some fcales, alfo membranaceous and very channelled, may alfo perform the office of legs: of thefe the two lower are the largeft. Its belly is filled with vermicular inteftines of the fize of a hair; its mouth is placed between the firft and fecond pair of legs, and is of the form of a fmall trunk placed between two lips, joined only at the upper extremity. Plate XXXI.

Fig. 2. reprefents an infect of the genus *onifcus*, *Linn.* Its body is nearly of the form, confiftence, and colour, of the *onifcus afellus*, except that it is not divided.

vided by segments as this last is. It has a double tail, three times as long as the body; from the insertion of which, at the hinder part of the body, spring two legs, used chiefly by the animal in swimming upon its back. The insect, viewed on the lower part H, presents six pair of legs; the two first of which terminate in very sharp and thick points; it makes use of the third to swim with, and to balance its body, together with that pair which is inserted at the base of the tail; the fourth pair, and the largest of all, is armed with two very sharp points, which the animal forces into the body of any fish on which it seizes; the two last pair are nothing more than very finely divided membranes. Between the two first is situated its trunk, smooth, and about half a line long; at the base of the third pair are two points, of a horny consistence, very hard, and firmly fixed. The two horns also below the large pair of legs are, in like manner, very firmly united to its body. Martiniere imagines it to be by means of these darts that it pierces the body of the fish on which it is found, and that then, changing it situation, it finds means to introduce its trunk into the holes thus formed, When put into a glass it sinks to the bottom, and rises again to the surface with the greatest ease, advancing with the edge of its body, and describing curves. Its two long tails are very easily pulled off, without the animal appearing to suffer any pain.

OPAQUE, not translucent, nor transparent, or not admitting a free passage to the rays of light.

OPARO or OPARRO, the name given by Captain Vancouver to a small island which he discovered in latitude 27° 36′ south, and in longitude 215° 49′ east from Greenwich. It was estimated at about 6½ miles in length, and no other land was in sight. Its principal character is a cluster of high craggy mountains, forming, in several places, most romantic pinicles, with perpendicular cliffs nearly from their summits to the sea: the vacancies between the mountains would more properly be termed chasms than valleys. The tops of six of the highest hills bore the appearance of fortified places, resembling redoubts; having a sort of block-house, in the shape of an English glass-house, in the centre of each, with rows of pallisadoes a considerable way down the sides of the hills, nearly at equal distances. These overhanging, seemed intended for advanced works, and apparently capable of defending the citadel by a few against a numerous host of assailants. On all of them people were noticed as if on duty, constantly moving about. What we considered (says the author) as block-houses, from their great similarity in appearance to that sort of building, were sufficiently large to lodge a considerable number of persons, and were the only habitations we saw. Yet, from the number of canoes that in so short a time assembled round the English ship, it is natural to conclude, that the inhabitants are very frequently afloat; and to infer, that the shores, and not those fortified hills which appeared to be in the centre of the island, would be preferred for their general residence.

Whether the fortified places here described were intended for defences of the islanders against each other, or against attacks from some more powerful neighbours, could only be conjectured; but the latter idea seems the most probable. From the language of the people, and their resemblance to the Friendly islanders, Captain Vancouver considers them all as having sprung from the same original stock. The people of Oparo, however, are distinguished by two circumstances, certainly in their favour. Not one of them was tattowed; and though they appeared not to have ever seen a European before, they all seemed perfectly well acquainted with the uses to which they could apply iron, and preferred articles of it to looking glasses, beads, and other trinkets, with which savages are usually delighted. Though there appeared to be anchoring ground near the north-west end of the island, circumstances rendered it inconvenient for Captain Vancouver to land on it; so that we are yet in a great measure strangers to the dispositions of the people, though they appeared to be hospitable.

OPEN FLANK, in fortification, is that part of the flank which is covered by the orillon or shoulder.

OPENING *of the Trenches*, is the first breaking of ground by the besiegers, in order to carry on their approaches towards a place.

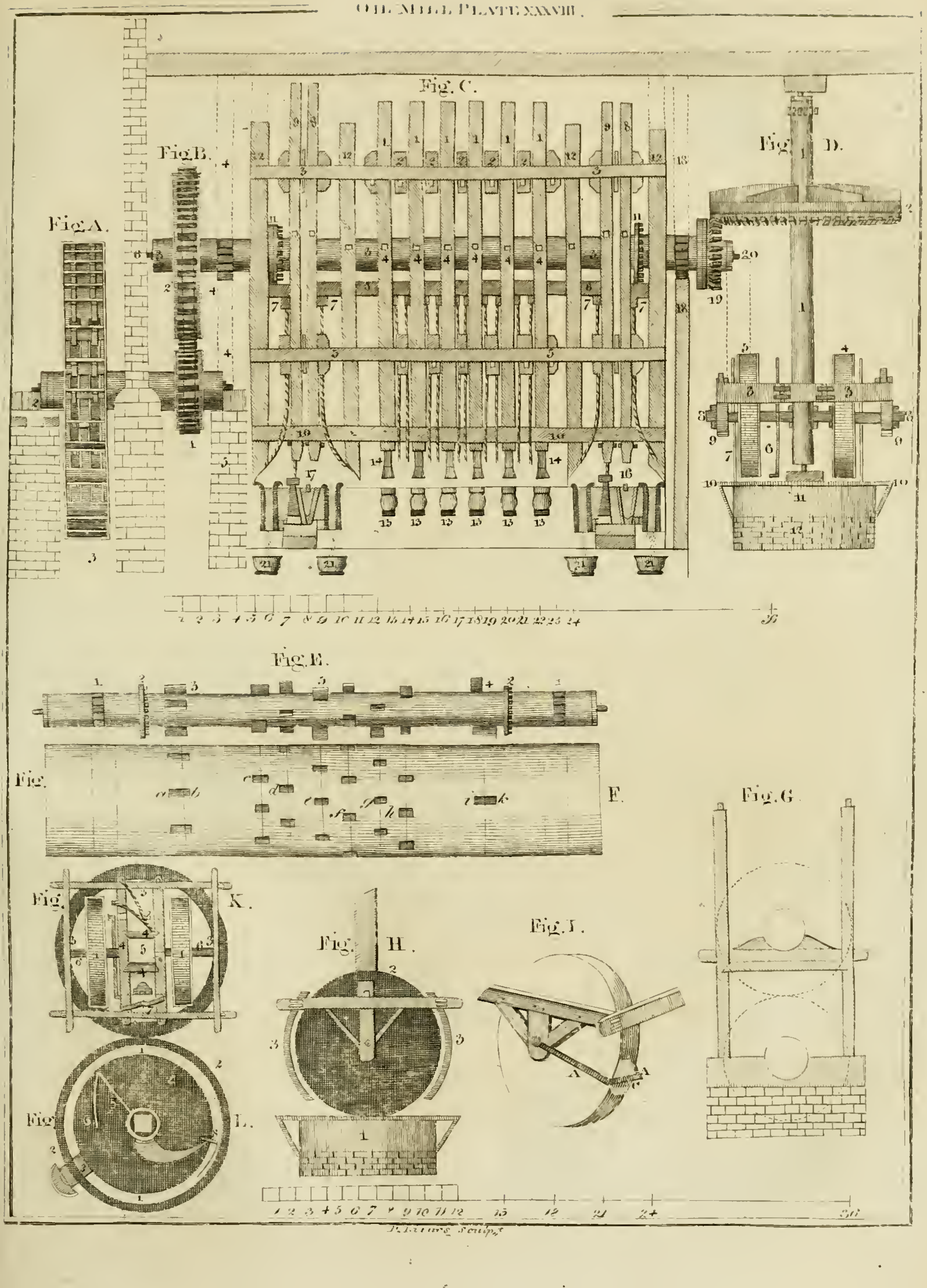
OPERA GLASS, is a diagonal perspective, of which the following concise and perspicuous description is taken from Dr Hutton's Mathematical Dictionary.—ABCD (Plate XLI.) represents a tube about four inches long; in each side of which there is a hole EF and GH, exactly against the middle of a plane mirror IK, which reflects the rays falling upon it to the convex glass LM; through which they are refracted to the concave eye-glass NO, whence they emerge parallel to the eye at the hole *r s*, in the end of the tube. Let P *a* Q be an object to be viewed, from which proceed the rays P *c*, *a b*, and Q *d*: these rays, being reflected by the plane mirror IK, will shew the object in the direction *c p*, *b a*, *d q*, in the image *p q*, equal to the object PQ, and as far behind the mirror as the object is before it: the mirror being placed so as to make an angle of 45 degrees with the sides of the tube. And as, in viewing near objects, it is not necessary to magnify them, the focal distances of both the glasses may be nearly equal; or, if that of LM be three inches, and that of NO one inch, the distance between them will be but two inches, and the object will be magnified three times, being sufficient for the purposes to which this glass is applied.

When the object is very near, as XY, it is viewed through a hole *x y*, at the other end of the tube AB, without an eye-glass; the upper part of the mirror being polished for that purpose as well as the under. The tube unscrews near the object-glass LM, for taking out and cleansing the glasses and mirror. The position of the object will be erect through the concave eye-glass.

The peculiar artifice of this glass is to view a person at a small distance, so that no one shall know who is observed; for the instrument points to a different object from that which is viewed; and as there is a hole on each side, it is impossible to know on which hand the object is situated which you are viewing. It is chiefly used in play-houses; and hence its name: but we have seen it most indecently employed by those who should have set a better example, even in a cathedral church!

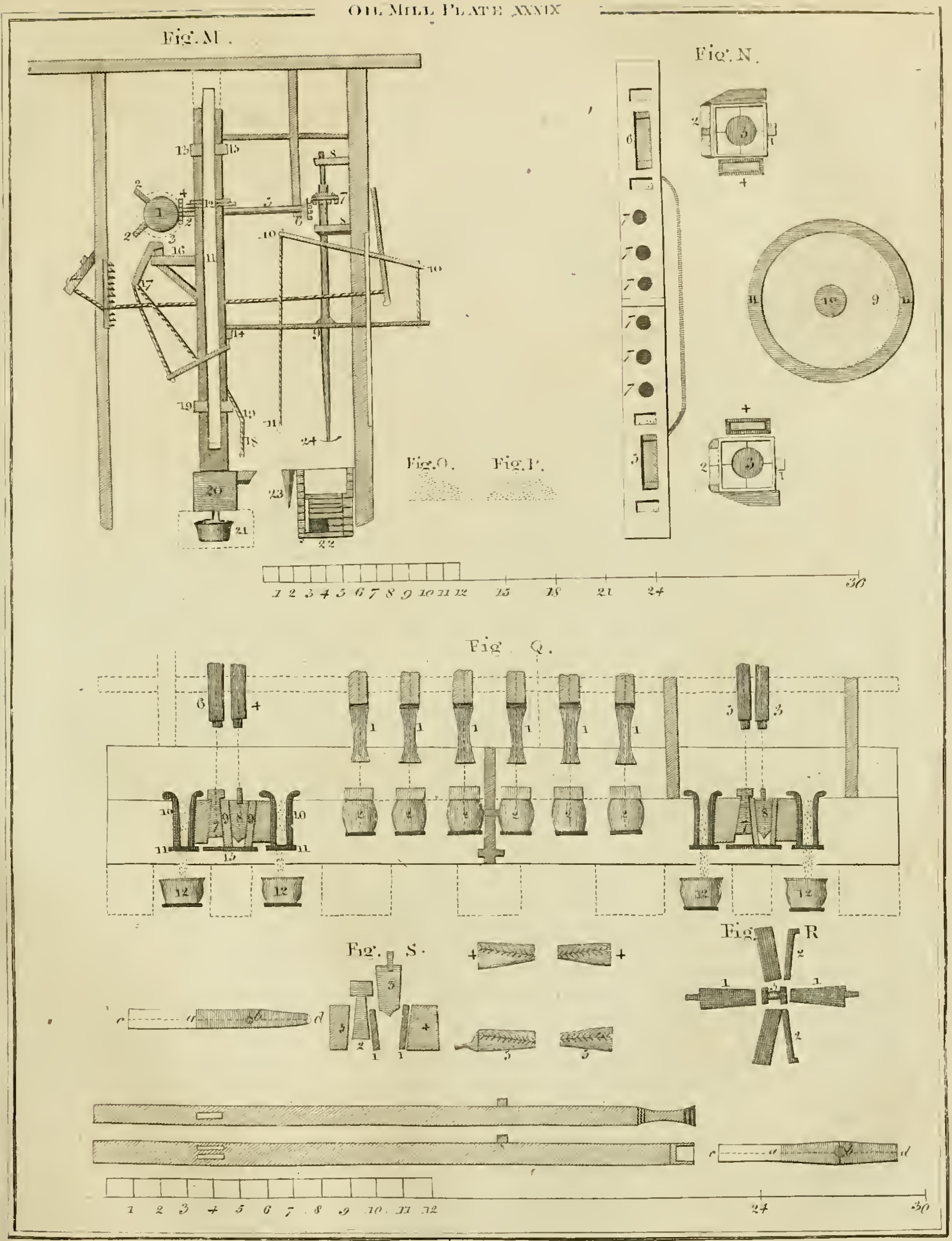
OPHRYS (See *Encycl.*), A new species of this plant has been lately described in the *Annual Hampshire Repository*, by a Fellow of the Linnean Society, in the following words:

" *Stem*—about 12 inches high, erect, stipulate, geniculate,



T. Evans Sculpt.

OIL MILL PLATE XXXIX



D. Lizars Sculpt.

culate, pubefcent at the upper genicles. *Spike*—ftrictly fpiral, flowers fpirally afcending, about 24, brightly white. Upper petal ovato-acuminate, pubefcent, lightly ciliate, ftraight. Two middle *petals* oblong-recurved. Two lower *petals* oblong-acuminate, lightly ciliate only on the lower fide near the bafe, projecting like elephant's tufks. *Nectary*, broad, recurved, ragged, bicipitate. *Leaves floral*—carinate acuminate, ciliate reaching and pointing to the middle of the flowers. *Leaves radical* —five or fix, about fix inches long, narrow, attenuate both ways, acuminate, the lower more haftate. *Leaves cauline*—lanceolate, alternate.

"Obfervation —This plant has much the habit, as well as autumnal florefcence, of Oriental fpiralis, and is fo perfectly fpiral alfo, that the fpecific name of the other fhould be altered, as being no longer exclufively fpiral; at the fame time that a fpecific name fhould be given to this: neither of which (fays the author) I fhall prefume to do, but fhall fuggeft it to the Linnean Society, of which I have the honour to be a Fellow."—This ophrys flowered, for the firft time, it is believed, in England, in Hampfhire, October 1796.

OPHIUCUS, a conftellation of the northern hemifphere; called alfo *Serpentarius*.

OPIUM (See *Encycl.*), is a medicine of fuch intrinfic value, and of fo high a price, that every method which promifes to increafe the quantity in the market muft be of importance. It was therefore, with much propriety, that *The Society for the Encouragement of Arts*, &c. fome time ago, voted 50 guineas to Mr John Ball of Williton, Somerfetfhire, for the difcovery of his method of preparing opium from poppies of the growth of England. The poppies, which he recommends as the moft productive, are the *double* or *femi-double*, of a dark colour; the feeds of which he advifes to be fown the latter end of February, and again about the fecond week in March, in beds three feet and a half wide (well prepared with good rotten dung, and often turned or ploughed, in order to mix it well, and have it fine), either in fmall drills, three in each bed, in the manner fallads are fown, and when about two inches high, to thin them one foot apart; or otherwife, to fow them in beds, in the broad-caft way, and thin them to the fame diftance. If they be kept free from weeds, they will grow well, and will produce from four to ten heads, fhewing large and different coloured flowers; and when their leaves die away, and drop off, the pods then being in a green ftate, is the proper time for extracting the opium, by making fuch longitudinal incifions as are, for this purpofe, made in the eaft (See OPIUM and PAPAVER, *Encycl.*). Immediately on the incifion being made, a milky fluid will iffue out; which is the opium, and which, being of a glutinous nature, will adhere to the bottom of the incifion; but fome poppies are fo productive, that it will drop from the pod on the leaves underneath The next day, if the weather fhould be fine, and a good deal of funfhine, the opium will be found a greyifh fubftance, and fome almoft turning black: it is then to be fcraped from the pods, and (if any there) from the leaves, with the edge of a knife, or other inftrument for that purpofe, into pans or pots; and in a day or two it will be of a proper confiftence to make into a mafs, and to be potted.

According to Mr Ball, fields cannot be fown with any thing more lucrative to the farmer than poppies, efpecially if thofe fields have a fouth expofure. "By a calculation (fays he) which I have made, fuppofing one poppy to grow in one fquare foot of earth, and to produce only one grain of opium, more than L.50 will be collected from one ftatute acre of land: but if we confider that one poppy produces from three or four to ten heads, that in each head from fix to ten incifions may be made, and that from many of them (I mean from one incifion) I have taken away two or three grains of opium—What muft then be the produce?"

Mr Ball produced to the Society letters from Dr Latham of Bedford-row, Dr Pearfon of Leicefter-fquare, and Mr Wilfon of Bedford-ftreet, declaring, that, in their opinion, his Englifh opium is equal in effect, and fuperior in purity, to the beft foreign opium.

OPTIC INEQUALITY, in aftronomy, is an apparent irregularity in the motions of far diftant bodies; fo called, becaufe it is not really in the moving bodies, but arifing from the fituation of the obferver's eye. For if the eye were in the centre, it would always fee the motions as they really are.

OPTIC *Pyramid*, in perfpective, is a pyramid formed by the vifible object which is the *bafe*, and the rays drawn from the perimeter of that object, which meet at the eye in a point, which is the *apex* of the pyramid. Hence, alfo, we may know what is meant by an *optic triangle*.

OPTIC *Rays*, particularly means thofe by which an optic pyramid, or optic triangle, is terminated.

ORAN, a confiderable city, occupied by the Spaniards, in the province of *Mafcara*, in the country of Algiers. It has ftrong and regular fortifications, and can eafily be fupplied from Spain with provifions and warlike ftores. It lies in 35′ of longitude weft from Greenwich, and in 35° 55′ north latitude. Since the year 1732, the Spaniards have held uninterrupted poffeffion of Oran. It has a parifh church, three monafteries, an hofpital: and the number of the inhabitants, according to the account given of it by the Spaniards, amount to 12,000. Towards the fea, the city rifes in the form of an amphitheatre, and is furrounded with forts and batteries. Clofe to the city lies a ftrong caftle, *Alcazava*, in which the Spanifh governor refides. On the higheft hill ftands Fort St Croix, whofe guns command the city and the adjacent country. From this fort they make fignals of the approach of fhips, and carefully watch the motions of the Moors, who often attempt predatory incurfions into the neighbouring diftricts. A confiderable number of Mahomedans take refuge in Oran; they dwell in a diftinct part of the city, receive pay from the court of Spain, and render fignal fervices againft the Moors. The greateft part of the inhabitants of Oran confifts of fuch as have been banifhed from Spain; and the fame may, in a great meafure, may be faid of the foldiers who compofe the garrifon. Five regiments are commonly ftationed here; but owing to continual defertion, their ftrength fcarcely equals that of four complete regiments. One of them wholly confifts of malefactors, who have been condemned to remain here for life; the reft are fuch as have been tranfported for one or more years. There is here likewife a military fchool. Around the city are pleafant gardens; but it is very dangerous to cultivate them, on account of the Moors and Arabs, who frequently lie in ambufh among them. The fame reafon prevents the cultivation of the fields in the vicinity; and the garrifon and inha-

inhabitants muft be fupplied with provifions immediately from Spain.

ORANGE-MEN, an appellation affumed by certain focieties in Ireland, of which the firft was formed in the county of Armagh, on the 21ft of November 1795, others in fome towns of Ulfter and Leinfter in the year 1797, another in the city of Dublin 1798; and fince that period, thefe focieties have fpread over the whole of our fifter kingdom. The object of thefe affociations is exhibited in the following authentic *Declaration of the Principles of Orange-men*, publifhed 1799.

" From the various attempts that have been made to poifon the public mind, and flander thofe who have had the fpirit to adhere to their king and conftitution, and to maintain the laws:—

" We, the Proteftants of Dublin, affuming the name of Orange-men, feel ourfelves called upon, not to vindicate our principles, for we know that our honour and loyalty bid defiance to the fhafts of malevolence and difaffection, but openly to avow thofe principles, and declare to the world the objects of our inftitution.

" We have long obferved, with indignation, the efforts that have been made to foment rebellion in this kingdom, by the feditious, who have formed themfelves into focieties, under the fpecious name of *United Irifhmen*.

" We have feen with pain the lower orders of our fellow-fubjects, forced or feduced from their allegiance, by the threats or machinations of *traitors*.

" And we have viewed with horror the fuccefsful exertions of *mifcreants*, to encourage a foreign enemy to invade this happy land, in hopes of rifing into confequence on the downfal of their country.

" We therefore thought it high time to rally round the conftitution, and there pledge ourfelves to each other, to maintain the laws, and fupport our good king againft all his enemies, whether *rebels* to their God or to their country; and by fo doing, fhew to the world that there is a body of men in this ifland, who are ready, in the hour of danger, to ftand forward in defence of that grand palladium of our liberties, the conftitution of Great Britain and Ireland, obtained and eftablifhed by the courage and loyalty of our anceftors under the Great King William.

" Fellow fubjects, we are accufed with being an *inftitution*, founded on principles too fhocking to repeat, and bound together by oaths, at which human nature may fhudder: but we caution you not to be led away by fuch malevolent falfehoods; for we folemnly affure you, in the prefence of the Almighty God, that the idea of injuring any one, on account of his religious opinion, never entered into our *hearts:* we regard every loyal fubject as our friend, be his religion what it may; we have no enmity but to the enemies of our country.

" We further declare, that we are ready, at all times, to fubmit ourfelves to the orders of thofe in authority under his Majefty, and that we will cheerfully undertake any duty which they fhall think proper to point out for us, in cafe either a foreign enemy fhall dare to invade our coafts, or that a domeftic foe fhall prefume to raife the ftandard of rebellion in the land. To thefe principles we are pledged—and in fupport of them we are ready to fpend the laft drop of our blood—(Signed) Thomas Verner, *Grand Mafter*; John Clau. Beresford, *Grand Secretary*; William James, J. De Joncourt, Edward Ball."

ORCHARD. As an appendix to this article in the *Encycl.* fome of our readers will be pleafed with the following means, employed by the Rev. Mr *Germerfhaufen*, for promoting the growth of young trees, and increafing the fize and flavour of the fruit in orchards.

Having planted feveral young plum trees in an orchard, he covered the ground, for fome years, around the trunks, as far as the roots extended, with flax-fhows (A); by which means thefe trees, though in a grafs-field, increafed in a wonderful manner, and far excelled others planted in cultivated ground. As far as the fhows reached, the grafs and weeds were choaked; and the foil under them was fo tender and foft, that no better mould could have beeen wifhed for by a florift.

When he obferved this, he covered the ground with the fame fubftance, as far as the roots extended, around an old plum-tree, which appeared to be in a languifhing ftate, and which ftood in a grafs-field. The confequences were, that it acquired a ftrong new bark; produced larger and better-tafted fruit; and that thofe young fhoots, which before grew up around the ftem, and which it was every year neceffary to deftroy, were prevented from fprouting forth, as the covering of flax-fhows impeded the free accefs of air at the bottom of the trunk.

In the year 1793, he tranfplanted, from feed-beds, into the nurfery, feveral fruit-trees; the ground around fome of which he covered, as above, with flax-fhows. Notwithftanding the great heat of the fummer, none of thofe trees where the earth was covered with fhows died or decayed; becaufe the fhows prevented the earth under them from being dried by the fun. Of thofe trees, around which the ground was not covered as before mentioned, the fourth part mifcarried; and thofe that continued alive were far weaker than the former.

The leaves which fall from trees in autumn may alfo be employed for covering the ground in like manner; but ftones, or logs of wood, muft be laid on them, to prevent their being difperfed by the wind. In grafsland, a fmall trench may be made around the roots of the tree, when planted, in order to receive the leaves. If flax-fhows are ufed, this is not neceffary; they lie on the furface of the ground fo faft as to refift the force of the moft violent ftorm. The leaves which our author found moft effectual in promoting the growth and fertility of fruit trees, are thofe of the walnut-tree. Whether it is, that, on account of their containing a greater abundance of faline particles, they communicate manure to the ground, which thereby becomes tender under them; or that they attract nitrous particles from the atmofphere; or that, by both thefe means, they tend to nourifh the tree both above and below.

Thofe who are defirous of raifing tender exotic trees from the feed, in order to accuftom them to our climate, may, when they tranfplant them, employ flax-fhows with

(A) Shows are the refufe of flax when it is fcutched or heckled.

with great advantage. This covering will prevent the frost from making its way to the roots; and rats and mice, on account of the sharp prickly points of the flax-shows, will not be able to shelter themselves under them.

ORCHILLA, a weed used in dyeing, which grows in the Canary islands, and is monopolized by the government. "It is a minute vegetable (says Sir George Staunton), of the lichen kind, growing chiefly upon rocks of a loose texture, and produces a beautiful violet blue colour."

ORDEAL. See this article in the *Encyclopædia*, at the end of which we have given, from Dr Henry's History of England, some strong reasons for suspecting that the ordeal, by fire at least, was a gross imposition on the credulity of an ignorant and superstitious age. This suspicion of imposture is raised to certainty by Professor Beckmann, who, in his History of Inventions, gives us the whole process by which the clergy conducted the trial, and brought proofs of innocence or of guilt at their pleasure. The person accused was put entirely under their management for three days before the trial, and for as many after it. They covered his hands (when he was to lift red-hot iron) both before and after the proof; sealed and unsealed the covering. The former was done, as they pretended, to prevent the hands from being prepared any how by art; the latter, that it might be accurately known whether or not they were burnt.

Some artificial preparation was therefore known, else no precautions would have been necessary. It is highly probable, that during the three first days the preventative was applied to those persons whom they wished to appear innocent; and that the three days after the trial were requisite to let the hands resume their natural state. The sacred sealing secured them from the examination of presumptuous unbelievers; for to determine whether the hands were burnt, the three last days were certainly not wanted. When the ordeal was abolished, and this art rendered useless, the clergy no longer kept it a secret. In the 13th century, an account of it was published by Albertus Magnus, a Dominican monk (A). If his receipt be genuine, it seems to have consisted rather in covering the hands with a kind of paste than in hardening them. The sap of the *althæa* (marshmallow), the slimy seeds of the flea-bane, which is still used for stiffening by the hat-makers and silk-weavers, together with the white of an egg, were employed to make the paste adhere. And by these means the hands were as safe as if they had been secured by gloves.

Hutton's Dictionary.

ORFFYREUS's WHEEL, in machanics, is a machine so called from its inventor, which he asserted to be a perpetual motion. This machine, according to the account given of it by Gravesande, in his *Oeuvres Philosophiques*, published by Allemand, Amst. 1774, consisted externally of a large circular wheel, or rather drum, 12 feet in diameter, and 14 inches deep; being very light, as it was formed of an assemblage of deals, having the intervals between them covered with waxed cloth, to conceal the interior parts of it. The two extremities of an iron axis, on which it turned, rested on two supports. On giving a slight impulse to the wheel, in either direction, its motion was gradually accelerated; so that, after two or three revolutions, it acquired so great a velocity as to make 25 or 26 turns in a minute. This rapid motion it actually preserved during the space of two months, in a chamber of the Landgrave of Hesse, the door of which was kept locked, and sealed with the Landgrave's own seal. At the end of that time it was stopped, to prevent the wear of the materials. The Professor, who had been an eye-witness to these circumstances, examined all the external parts of it, and was convinced that there could not be any communication between it and any neighbouring room. Orffyreus, however, was so incensed, or pretended to be so, that he broke the machine in pieces; and wrote on the wall, that it was the impertinent curiosity of Professor Gravesande which made him take this step. The Prince of Hesse, who had seen the interior parts of this wheel, but sworn to secrecy, being asked by Gravesande, whether, after it had been in motion for some time, there was any change observable in it, and whether it contained any pieces that indicated fraud or deception? answered both questions in the negative, and declared, that the machine was of a very simple construction.

ORICOU, a new species of the vulture, discovered by Vaillant at Orange river in South Africa. As he thinks it unquestionably the most beautiful of its genus, and tells us, as usual with him, a wonderful story about it, we have given a figure of this vulture in Plate XLI. Our traveller says, that it is more than three feet high, and eight or nine in breadth of wing. Its feathers, the general hue of which is a light brown, are of a particular kind on the breast, belly, and sides, where they are of unequal lengths, pointed, curved like the blade of a sabre, and bristle up distinct from each other. The feathers being thus separated, would disclose to view the skin on the breast, if it were not completely covered with a very thick and beautiful white down, which is easily seen between the ruffled plumage.

A celebrated naturalist has said, that "no bird has eye-lashes or eye-brows, or, at least, hair round the eyes like that in quadrupeds." This assertion, advanced as a general law of Nature, is a mistake. Not only the oricou has this peculiarity, but we know of many other species in which it exists; such as, in general, all the calaos, the secretary, and several other birds of prey. Beside these eye-lashes, the vulture in question has stiff black hairs on its throat. All the head and part of the neck are bare of feathers; and the naked skin, which is of a reddish colour, is dashed in certain places with blue, violet, and white. The ear, in its external circumference, is bounded by a prominent skin, which forms a sort

(A) In his work *De Mirabilibus Mundi*, at the end of his book *De Secretis Mulierum*, Amstelod. 1702, 12mo, p. 100. Experimentum mirabile quod facit hominem ire in ignem sine læsione, vel portare ignem vel ferrum ignitum sine læsione in manu. Recipe succum bismalvæ, et albumen ovi, et semen psylli et calcem, et pulveriza, et confice cum illo albumine ovi succum raphani; commisce; ex hac confectione illineas corpus tuum vel manum, et dimitte siccari, et postea iterum illineas, et post hoc poteris audacter sustinere ignem sine nocumento.

fort of rounded conch, that muft neceffarily heighten the faculty of hearing in this fpecies. This kind of conch is prolonged for fome inches, and defcends down the neck; which induced our author to give it the name of *oricou.*

Its ftrength, he fays, muft be very confiderable, if we may judge from its mufcles and finews; and he is perfuaded, that there is not a ftronger among the whole order of carnivorous birds, not excepting the famous condor, which fo many travellers have feen, but of which their defcriptions are fo different as to render its exiftence extremely doubtful. But there was no occafion for this reafoning, and thofe inferences, if what he relates as facts deferve any credit. The oricou which he defcribes, he firft perceived perched on the carcafe of a hippopotamos. eagerly devouring its flefh. He fhot at it, and wounded it flightly; upon which, "though it had already gorged itfelf with a confiderable quantity of flefh (for upon opening it, he found in its ftomach no lefs a quantity than *fix pounds and a half*), yet its hunger and voracity were fuch, that it ftruck its beak into the carcafe when attempting to take wing, as if defirous of carrying the whole of it away.

"On the other hand, the weight of the flefh it had devoured rendering it the more heavy, it could not eafily rife: fo that we had time (fays he) to reach it before it was on the wing, and we endeavoured to knock it on the head with the butt-ends of our mufkets. It defended itfelf a long time with great intrepidity. It bit or ftruck at our weapons with its beak, and its ftrength was ftill fo great, that every ftroke made a mark on the *barrel of the piece.*"

ORIENT, the eaft, or the eaftern point of the horizon.

Orient *Equinoctial,* is ufed for that point of the horizon where the fun rifes when he is in the equinoctial, or when he enters the figns Aries and Libra.

Orient *Aeftival,* is the point where the fun rifes in the middle of fummer, when the days are longeft.

Orient *Hybernal,* is the point where the fun rifes in the middle of winter, when the days are fhorteft.

OROTAVA, a town in the ifland of Teneriffe, at the bottom of thofe mountains out of which the Peek rifes, neatly built of ftone, on an irregular furface. The moft remarkable object near it is a dragon's blood tree, of which the trunk meafures, at the height of ten feet from the ground, 36 feet in girth. Concerning this tree there is a tradition current in the ifland, that it exifted, of no inconfiderable dimenfions, when the Spaniards made the conqueft of Teneriffe, about three centuries ago; and that it was then, what it ftill is, a landmark, to diftinguifh the boundaries of landed poffeffions near it.

Diftant about three miles on the fea-coaft is the puerto, or fea-port, of Orotava, where is carried on a confiderable degree of commerce, principally for the exportation of wine. It is chiefly, as at Madeira, in the hands of a few Britifh commercial houfes, which import, in return, the manufactures of Great Britain. Within a mile is a collection of living plants from Mexico, and other parts of the Spanifh dominions in America. From hence they are to be tranfplanted into Spain. It is an eftablifhment of fome expence; and, whatever may be its fuccefs, it fhews a laudable attention, on the part of that government, to the promotion of natural knowledge.

OROTCHYS and Bitchys, two tribes of Tartars, who were vifited by La Peroufe in 1787, and of whofe manners he gives fuch an account as renders it difficult to fay whether they have the beft claim to be called a favage or a civilized people. He fell in with a fmall village of them on the eaft coaft of Tartary, in a bay to which he gave the name of *Baie de Caftrie,* in Lat. 51° 29′ North, and Long. 139° 39′ Eaft from Paris.

Their village, their employment, their drefs, and their apparent ignorance of all religion, befpoke them favages. Their village was compofed of four cabins, built in a foid manner, of the trunks of fir-trees, and covered with bark. A wooden bench compaffed the apartment round about; and the hearth was placed in the middle, under an opening large enough to give vent to the fmoke.

This village was built upon a tongue of low marfhy land, which appeared to be uninhabitable during the winter; but on the oppofite fide of the gulph, on a more elevated fituation, and expofed to the fouth, there was, at the entrance of a wood, another village, confifting of eight cabins, much larger and better built than the firft. Above this, and at a very fmall diftance, were three yourts, or fubterraneous houfes, perfectly fimilar to thofe of the Kamtfchadales, defcribed in the third volume of Captain Cook's laft voyage; they were extenfive enough to contain the inhabitants of the eight cabins during the rigour of the cold feafon; befides, on fome of the fkirts of this village were feen feveral tombs, which were larger and better built than the houfes; each of them enclofed three, four, or five biers, of a neat workmanfhip, ornamented with Chinefe ftuffs, fome pieces of which were brocade. Bows, arrows, lines, and, in general, the moft valuable articles of thefe people, were fufpended in the interior of thefe monuments, the wooden door of which was clofed by a bar, fupported at its extremities by two props.

Their fole employment feemed to be the killing and curing of falmon, of which they eat raw, the fnout, the gills, the fmall-bones, and fometimes the entire fkin, which they ftript off with infinite dexterity. When the ftript falmon were carried to the huts, the women, in the moft difgufting manner, devoured the mucilaginous part of them, and feemed to think it the moft exquifite food. Every cabin was furrounded with a drying place for falmon, which remain upon poles, expofed to the heat of the fun, after having been during three or four days fmoked round the fire, which is in the middle of their cabin; the women, who are charged with this operation, take care, as foon as the fmoke has penetrated them, to carry them into the open air, where they acquire the hardnefs of wood.

The bones of the falmon fo cured were fcattered, and the blood fpread round the hearth; greedy dogs, though gentle and familiar enough, licked and devoured the remainder. The naftinefs and ftench of this people are difgufting. There is not perhaps anywhere a race of people more feebly conftituted, or whofe features are more different from thofe forms to which we attach the idea of beauty; their middle ftature is below four feet ten inches, their bodies are lank, their voices thin and feeble, like that of children; they have high cheek bones, ſmall blear eyes, placed diagonally; a large mouth, flat noſe, ſhort chin, almoſt beardleſs, and an olive-coloured ſkin, varniſhed with oil and ſmoke. They ſuffer their hair to grow, and tie it up nearly the ſame as we do; that of the women falls looſe about their ſhoulders, and the portrait which has juſt been drawn agrees equally well with their countenances as thoſe of the men, from whom it would be difficult to diſtinguiſh them, were it not for a ſlight difference in the dreſs, and a bare neck; they are not, however, ſubjected to any labour, which might, like the American Indians, change the elegance of their features, if nature had furniſhed them with this advantage. Their whole cares are limited to the cutting and ſewing their clothes, diſpoſing of their fiſh to be dried, and taking care of their children, to whom they give the breaſt till they are three or four years of age.

With reſpect to dreſs, the men and little boys are clothed with a waiſtcoat of nankeen, or the ſkin of a dog or a fiſh, cut in the ſhape of a waggoner's frock. If it reach below the knee, they wear no drawers; if it do not, they wear ſome in the Chineſe ſtyle, which fall as low as the calf of the leg. All of them have boots of ſeal's ſkin, but they keep them for the winter; and they at all times, and of every age, even at the breaſt, wear a leather girdle, to which are attached a knife in a ſheath, a ſteel to ſtrike a light with, a pipe, and a ſmall bag to contain tobacco. The dreſs of the women is ſomewhat different; they are wrapped up in a large nankeen robe, or ſalmon's ſkin, which they have the art of perfectly tanning, and rendering extremely ſupple. This dreſs reaches as low as the ankle-bone, and is ſometimes bordered with a fringe of ſmall copper ornaments, which make a noiſe ſimilar to that of ſmall bells. Thoſe ſalmon, the ſkins of which ſerve for clothing, are never caught in ſummer, and weigh thirty or forty pounds.

Though they had neither prieſts nor temples, they ſeemed to be believers in ſorcery, and took the motion of the Frenchmens hands, when writing, for ſigns of magic. Thus far they appeared ſavages.

Their ſacred regard of property, their attention to their women, and the delicacy of their politeneſs to ſtrangers, would, on the other hand, do honour to the moſt civilized nation. While Perouſe and his people were in the bay, one of the families took its departure on a voyage of ſome length, and did not return during their ſtay. When he went away, the maſter of the family put ſome planks before the door of his houſe, to prevent the dogs from entering it, and in this ſtate left it full of their effects. "We were ſoon (ſays our author) ſo perfectly convinced of the inviolable fidelity of theſe people, and their almoſt religious reſpect for property, that we left our ſacks full of ſtuffs, beads, iron tools, and, in general, every thing we uſed as articles of barter, in the middle of their cabins, and under no other ſeal of ſecurity than their own probity, without a ſingle inſtance of their abuſing our extreme confidence; and on our departure from this bay, we firmly entertained the opinion, that they did not even ſuſpect the exiſtence of ſuch a crime as theft."

Their attention to their women, ſo uncommon among ſavages, was diſplayed in their exempting them from hard labour; in their never concluding a bargain with the Frenchmen without previouſly conſulting their wives; and in their reſerving the pendent ſilver ear-rings and copper trinkets, which they purchaſed, for their wives and daughters. Of the delicacy of their manners to ſtrangers, we ſhall give the following intereſting inſtance in the words of Perouſe's tranſlator:

Obſerving with what repugnance they received preſents, and how often they refuſed them with obſtinacy, "I imagined (ſays Perouſe) I could perceive, that they were perhaps deſirous of more delicacy in the manner of offering them; and to try if this ſuſpicion were well founded, I ſat down in one of their houſes, and after having drawn towards me two little children, of three or four years old, and made them ſome trifling careſſes, I gave them a piece of roſe-coloured nankeen, which I had brought in my pocket. The moſt lively ſatisfaction was viſibly teſtified in the countenances of the whole family, and I am certain they would have refuſed this preſent, had it been directly offered to themſelves. The huſband went out of his cabin, and ſoon afterwards returning with his moſt beautiful dog, he entreated me to accept of it. I refuſed it, at the ſame time endeavouring to make him underſtand, that it was more uſeful to him than to me: but he inſiſted; and perceiving that it was without ſucceſs, he cauſed the two children, who had received the nankeen, to approach, and placing their little hands on the back of the dog, he gave me to underſtand, that I ought not to refuſe his children.

"The delicacy of ſuch manners cannot exiſt but among a very poliſhed people. It ſeems to me, that the civilization of a nation, which has neither flocks nor huſbandry, cannot go beyond it. It is neceſſary to obſerve, that dogs are their moſt valuable property; they yoke them to ſmall and very light ſledges, extremely well made, and exactly ſimilar to thoſe of the Kamtſchadales. Theſe dogs, of the ſpecies of wolf dogs, and very ſtrong, though of a middle ſize, are extremely docile, and very gentle, and ſeem to have imbibed the character of their maſters."

ORTHODROMICS, in navigation, is great-circle ſailing, or the art of ſailing in the arch of a great circle, which is the ſhorteſt courſe: For the arch of a great circle is *orthodromia*, or the ſhorteſt diſtance between two points or places.

ORYCTEROPUS, the name given by M. Geoffroy, profeſſor of zoology in the French muſeum of natural hiſtory, to the animal called by other zoologiſts *Myrmecophaga Capenſis*. (See MYRMECOPHAGA, *Encycl.*) He conſiders it as a diſtinct genus, and ſeems indeed to have proved, by a compariſon of the organs of the orycteropus with thoſe of the *tatous daſipus* of Linnæus, and of the *myrmecophagi*, that this genus is intermediate, by its forms and habits, between thoſe two families. It approaches to the *tatous* in its organs of maſtication, and the form of the toes and nails, and in having a ſhort and ſingle cæcum, whilſt that of the myrmecophagi is double, as in birds, by the reuniting of the bones of the os pubis, which are not articulated together in the myrmecophagi. The orycteropus, however, bears a relation to the laſt, ſince it has, like them, a very ſmall mouth, whence its tongue, covered with hair, may be protruded to a conſiderable length. Finally, the habits of the orycteropus reſemble thoſe of the animals to which it approaches the moſt; it does not climb trees, but lives under the earth like the tatous;

Oryćtero-pus || Ouadelim.

tous; it feeds like them on roots, but also it hunts after anthills, like the myrmecophagi. Its snout terminates in a blunt callous; a character which is peculiar to it. It may be distinguished in the works of naturalists by the following description:

Oryćteropus. Molar teeth (six) with flat vertices; the body covered with hair.

The oryćteropus, as appears from the preceding, connects the tatous with the myrmecophagi and with the *pangolin manis* of Linnæus. The large fossile species found in Paraguay, for which Citizen Cuvier has established a new genus, under the name of *megaterium*, is intermediate between the sloth and the myrmecophagus; and, lastly, the astonishing animal of New Holland, covered with bristles like the porcupine, supported by very short legs, and of very singular conformation, and with a head round at the occiput, terminating in a snout, without teeth, very slender, long, and cylindrical, and described by Mr George Shaw under the name of myrmecophaga aculeata, appears to have very striking relations to the pangolin and the oryćteropus; from hence it follows, that in consequence of these important acquisitions, we ought for the future to count, in the number of our natural orders, that of the *edentated*, or *edented*, consisting of the following genera: *Dasipus*, *oryćteropus myrmecophaga*, and *aculeata*, *manis*, *myrmecophaga*, *megaterium* et *bradypus*.

OSCILLATION, in mechanics, vibration, or the reciprocal ascent and descent of a pendulum.

Axis of Oscillation, is a line parallel to the horizon, supposed to pass through the centre or fixed point about which the pendulum oscillates, and perpendicular to the plane in which the oscillation is made.

Centre of Oscillation, in a suspended body, is a certain point in it, such that the oscillations of the body will be made in the same time as if that point alone were suspended at that distance from the point of suspension. Or it is the point into which, if the whole weight of the body be collected, the several oscillations will be performed in the same time as before: the oscillations being made only by the force of gravity of the oscillating body.

OSCULATION, in geometry, denotes the contact between any curve and its osculatory circle; that is, the circle of the same curvature with the given curve, at the point of contact or of osculation. See Involution in this *Suppl.*

Osculation also means the point of concourse of two branches of a curve which touch each other. For example, if the equation of a curve be $y = \sqrt{x} + \sqrt[4]{x^3}$, it is easy to see that the curve has two branches touching one another at the point where $x = 0$, because the roots have each the signs + and —.

OUADELIM and Labdesseba, two tribes of Arabs inhabiting the *Sahara* or Great Desart of Africa, of whom almost nothing was known to Europeans till the publication of Brisson's narrative of his shipwreck and captivity among the latter tribe. He describes the Ouadelim and Labdesseba as the most formidable of all the interior tribes of Arabs, and as often extending their ravages to the very gates of Morocco. "Their hordes (he says) are frequently intermingled with those of the Rousege, Rathidium, Chelus, Tucanois, and Ouadeli tribes, as they have no distinct boundaries, and change their habitations as the desart affords pasturage and water. They are tall, handsome, stout, and vigorous men. Their hair is bristled, and their nails, which they often use in battle, as long as claws; large hanging ears and a long beard give them a stern ferocious air. The Ouadelim in particular are fierce, arrogant, and warlike, but soon dispirited by obstinate resistance, especially when they have not a decided superiority in numbers. In their hordes they lodge by families, in tents which are covered with a thick cloth of camels hair, which the women spin and weave upon a loom so small, that they work sitting on the ground. The furniture of their tents consist of two large sacks of leather, in which they keep old clothes, and pieces of old iron, three or four goat skins for holding milk and water, two large stones for grinding their barley, a smaller one for driving the pins of their tents, an ozier matting which serves for a bed, a thick carpet for a covering, a small kettle, and some wooden dishes, with pack-saddles for their camels. The person who, besides these articles, possesses a few horses, camels, sheep, and goats, is reckoned wealthy, as there are many Arabs who only possess sheep and goats. Except sore eyes and the cholic, they are subject to few endemic diseases. The first disorder is caused by the reflection of light from the burning sands of the desart, the other proceeds from the verdigrease which contaminates all their victuals. Their kettles are not tinned, and never washed, so that they are quite crusted over with verdigrease, the virulence of which is probably diminished by the quantity of milk they use. When they reside long in one place, they sometimes plough the spots which are moistened by the rain, and sprinkle them with seed in a careless manner. Plentiful crops are often thus produced; but instead of waiting till the grain attains maturity, they cut it down, and dry it over hot cinders. Treachery and perfidy are the innate vices of the Arabs; assassinations are frequent; no man trusts the promise of another; no man makes a written agreement, as the poignard cancels all bonds and obligations. The men often relate their exploits to each other; the embellishing of a story is succeeded by a charge of falsehood, and the poignard solves every difficulty. The ancient rites of hospitality, however, are practised among these tribes in their utmost extent. The Arab, who in the field is a rapacious plunderer, becomes liberal and generous as soon as he enters his tent. War is only a species of rapine, and the victory is decided at the first shock. The Arab is devoid of sanguinary courage; he attacks only to plunder, and never thinks that booty is to be put in competition with his life. When the battle is ended, each party makes graves for the slain, and enclose the tombs with mounds of stones. The ages of the warriors are denoted by the space of ground which the grave occupies, and the funeral procession is closed by the howls of the females.

"The women never assume the name of their husbands, and never eat with them at meals. They are faithful to their husbands, and cannot be divorced except by the decree of the seniors of the horde. The Arabs display their opulence by the ornaments of their women, whose ears, arms, and legs, are generally adorned with rings of gold and silver. An Arab beauty must have long teeth shooting out of her mouth, a body extremely thick, and limbs of the longest size. At the birth of a son, every woman, to testify her joy, blackens

Ouadelim. ens her face for 40 days. At the birth of a daughter, ſhe only daubs the half of her face during the ſpace of 20 days. A mother treats her ſon with the ſame reſpect as her huſband, almoſt as ſoon as he is able to walk; ſhe prepares his food, ſerves him, and eats when he has finiſhed his repaſt. In the education of their young men, the moſt important acquiſitions are, dexterity in the uſe of the poignard, ſkill in embowelling their enemies with their long nails, and a plauſible air in uttering a falſehood. More rude and ferocious than the tribes whoſe territories lie upon the ſhore of the ſea, the Labdeſſeba and Ouadelim Arabs are alſo more confined and illiberal in their ideas, not only believing that they are the firſt nation in the world, but fancying that the ſun riſes only for them. Briſſon relates, that ſome of them expreſſed this idea in unequivocal terms. 'Behold (ſaid they) that luminary, which is unknown in thy country. During the night, thou art not enlightened, as we are, by that heavenly body, which regulates our days and our faſts. His children (the ſtars) point out to us the hours of prayer. You have neither trees nor camels, ſheep, goats, nor dogs. Are your women ſimilar to ours?' 'How long didſt thou remain in the womb of thy mother (ſaid another)?' 'As long (replied Briſſon) as thou in that of thine.' 'Indeed (ſaid a third, counting the fingers and toes of the Frenchman) he is made like us; he differs only in his colour and language.' 'Do you ſow barley in your houſes?' ſaid the Arabs, alluding to the ſhips of the Europeans. 'No (ſaid Briſſon), we ſow our fields almoſt in the ſame ſeaſon as you.' 'How! (cried ſeveral) do you inhabit the earth? we believed that you were born and lived upon the ſea.' Theſe Arabs, according to the Turkiſh proverb, believe that all the world is like their father's houſe: unacquainted with the manners of other nations, and unaccuſtomed to reflect upon the cauſes of national character, every variation from their own cuſtoms appears not only ridiculous, but monſtrous; every difference of opinion not only abſurd, but criminal. This ignorance of the Arabs, conjoined with their local and religious prejudices, enables us to account for the inſulting treatment which Briſſon and his companions received, without having recourſe to inherent depravity of nature." That treatment was indeed ſhocking.

Briſſon had ſurrendered himſelf, on his ſhipwreck, to Sidi Mahomet, a *Talbe* or prieſt of the tribe of Labdeſſeba. During the abſence of the prieſt, the Labdeſſeba, who guarded the captives, were attacked and maltreated by a party of the Ouadelims, and during the buſtle which enſued, Briſſon had almoſt loſt his life. Inſtead of compaſſionating his forlorn ſituation, the women threw ſand into his eyes, as they ſaid, to dry his eye-lids. The Arabs, into whoſe hands he had fallen, had only come down to the ſea-coaſt to gather wild grain, three days before the ſhipwreck; and to preſerve their booty, they immediately retreated to the interior part of the deſart. A guide preceded the horde, to place at intervals ſmall pyramids of ſtone, to direct their courſe, at a diſtance from every hoſtile tribe. After paſſing ſome very high mountains, wholly covered with ſmall greyiſh pebbles as ſharp as flints, they deſcended into a ſandy plain overſpread with thorns and thiſtles. When Briſſon was unable to walk, on account of the bleeding of his feet, he was mounted on a camel; the briſtly hair and hard trot of which ſoon excoriated him ſo much, that the blood run copiouſly down its flanks. By throwing heated ſtones into a wooden veſſel, filled with barley meal, diluted with water procured on the ſea-ſhore, preſerved in a goat's ſkin, and mixed with pitch to prevent putrefaction, the Arabs prepared a kind of ſoup, which they kneaded with their hands, and ate unchewed. They roaſted a goat in heated ſand, ate its fat raw, and, after having devoured the fleſh, gnawed the bones, and ſcraped them with their nails, threw them to Briſſon and his companions, deſiring them to eat quickly, and load the camels, that the journey might not be impeded. Proceeding eaſtward, they croſſed a vaſt plain, covered with ſmall ſtones white as ſnow, round and flat as a lental, where not a ſingle plant was produced. The earth beneath their feet reſounded dull and hollow, and the ſmall ſtones pricked them like ſparks of fire. The reflection of the rays of the ſun from the ſand was ſcorching; the atmoſphere was loaded with a red vapour, and the country appeared as if filled with flaming volcanoes. Neither birds nor inſects could be ſeen in the air. The profound ſilence was frightful. If a gentle breeze ever aroſe, it produced extreme languor, chopping of the lips, burning heat of the ſkin, with ſmall ſmarting pimples. This plain was even ſhunned by wild beaſts. After traverſing this plain, they entered another, where the wind had thrown up in furrows the ſand, which was of a reddiſh colour. On the tops of the furrows grew a few ſweet-ſcented plants, which were devoured by the camels. On quitting this ſandy plain, they entered a valley ſurrounded by mountains, where the ſoil was white and ſlimy, and where they found water of a noxious ſmell, covered with green moſs, and ſoon after diſcovered a horde of the friendly tribe Rouſſye.

After another journey of ſixteen days, they arrived at the tents of the Labdeſſeba horde, to which Sidi Mahomet belonged. The tents pitched among thick buſhy trees, and the numerous flocks feeding along the ſides of the hills, preſented at a diſtance an aſpect of happineſs and paſtoral ſimplicity. On approaching near, the trees of beautiful green foliage proved to be only old gummy ſtumps, almoſt void of branches, ſo encircled with thorns that their ſhade was inacceſſible. The women approached, with loud cries and the moſt fawning ſervility, to welcome their tyrants, to throw ſtones at the Chriſtians, and ſpit in their faces, while the children imitated the example of their mothers. Briſſon, who endeavoured to ingratiate himſelf with his maſter's favourite, not only failed in this, but incurred her implacable reſentment, through his irritability, which to the Arab women ſeemed extremely to reſemble petulance. During his reſidence with Sidi Mahomet, the hardſhips he endured were almoſt incredible. With the exceſſive heat, the milk of the ſheep, goats, and camels, diminiſhed, and then the dogs fared better than the Chriſtians, who were forced to ſubſiſt on wild herbs and raw ſnails. When the rains fell, and the leaſt preſſure made the water to ſpring up through the ſandy ſoil, the Chriſtians ſlept behind a buſh, unſheltered, on the bare ground. Briſſon and his maſter ſometimes reaſoned about religion; when the latter always anſwered the harangues of the former by declaring, that he preferred a bowl of churned milk to ſuch abſurdities.

absurdities. Several of his companions perished, and were left by the Arabs to be devoured by the ravens, while in the struggles of death. One of them was supposed to be murdered by his master for milking his camels clandestinely. An application made by Brisson to the consul at Mogador, by a letter entrusted to a Jewish merchant, was frustrated through the negligence of the vice-consul; and the Labdesseba Arabs thought the journey too dangerous to be encountered for the ransom of their slaves. He was, however, at last relieved, through the humanity of his master's brother-in-law, who carried him to Morocco, where his ransom was paid by the Emperor, and whence he returned to France. For a fuller account of these two savage tribes, see *Saugnier's and Brisson's Narratives*; or a very pleasing *Historical and Philosophical Sketch of the Discoveries, &c. of the Europeans in Northern and Western Africa*, published 1799 by *Symington* Edinburgh, and *Vernor* and *Hood* London.

OXYGLYCUS CERASUS, the name given by the Editor of Dalzel's History of Dahomy to a very singular fruit produced in that country, as well as in some other parts of Africa. It resembles a small olive in every respect but the colour; being of a dusky reddish hue, changing at the end next the stalk to a faint yellow. The pulp is firm, and almost insipid; the stone is hard like that of the olive. After having chewed one or more of such berries, and spit out or swallowed the pulp at pleasure, a glass of vinegar will taste, to the person trying the experiment, like sweet wine; a lime will seem to have the flavour of a very ripe China orange; and the same change is produced on other acids, the ordinary effects of which upon the palate is destroyed in a very unaccountable manner, without effervescence or any sensible motion. Indeed, the effect is very different from neutralization, arising from the mixture of acid and alkali; such combination producing a neutral saline liquor, whilst this miraculous berry seems to convert acids to sweets. Food or drink, not containing any acid, suffer no change by the previous use of this fruit; its effect upon acids continues, even after a meal, though in a much smaller degree. The natives use it to render palatable a kind of gruel called *guddoe*, which is made of bread after it becomes too stale for any other purpose. They describe it as the fruit of a large tree.

Plants six or seven inches high were raised from this fruit by Mr Dalzel, who tried to carry them from Angola to the botanic garden at St Vincent's; but they died on the passage. He preserved the berries in spirits, in syrup, and in a dry form; but they lost their singular quality in all those preparations. The plant is an evergreen, and the leaves in this infant state are like those of the olive.

OXY-MURIATIC ACID (See CHEMISTRY-*Index* in this *Suppl.*), is the principal agent in the new process of bleaching (see BLEACHING, *Suppl*); but, till very lately, at least, if not even at present, the bleachers were in the practice of adding some alkali to the acid, notwithstanding the strong objections which M. Bertholet made to that addition, and notwithstanding the proofs urged by Mr Rupp, that it increases the expence of bleaching about 40 *per cent.* The chief reason for persisting in a practice to which such objections were urged was, that the addition of the alkali deprives the liquor of its suffocating effects without destroying its bleaching powers. Mr Rupp, however, has contrived the following apparatus, in which may be safely used the pure oxy-muriatic acid simply dissolved in water, which is at once its cheapest and best vehicle.

Figure 1. (Plate XLI.) is a section of the apparatus. It consists of an oblong deal cistern ABCD, made water-tight. A rib EE of ash or beech wood is firmly fixed to the middle of the bottom CD, being mortised into the ends of the cistern. This rib is provided with holes at FF, in which two perpendicular axes are to turn. The lid AB has a rim GG, which sinks and fits into the cistern. Two tubes HH are fixed into the lid, their centres being perpendicularly over the centres of the sockets FF when the lid is upon the cistern. At I, is a tube by which the liquor is introduced into the apparatus. As it is necessary that the space within the rim GG be air-tight, its joints to the lid, and the joints of the tubes, must be very close; and, if necessary, secured with pitch. Two perpendicular axes KL, made of ash or beech wood pass through the tubes HH, and rest in the sockets FF. A piece of strong canvas M is sewed very tight round the axis K, one end of it projecting from the axis. The other axis is provided with a similar piece of canvas. N are pieces of cloth rolled upon the axis L. Two plain pulleys OO are fixed to the axis, in order to prevent the cloth from slipping down. The shafts are turned by a moveable handle P. Q is a moveable pulley, round which passes the cord R. This cord, which is fastened on the opposite of the lid (see fig. 2.), and passes over the small pulley S, produces friction by means of the weight T. By the spigot and fausset V, the liquor is let off when exhausted.

The dimensions of this apparatus are calculated for the purpose of bleaching twelve or fifteen pieces of $\frac{7}{8}$ calicoes, or any other stuffs of equal breadth and substance. When the goods are ready for bleaching, the axis L is placed on a frame in an horizontal position, and one of the pieces N being fastened to the canvas M by means of wooden skewers, in the manner represented in fig. 1. it is rolled upon the axis by turning it with the handle P. This operation must be performed by two persons; the one turning the axis and the other directing the piece, which must be rolled on very tight and very even. When the first piece is on the axis, the next piece is fastened to the end of it by skewers, and wound on in the same manner as the first. The same method is pursued till all the pieces are wound upon the axis. The end of the last piece is then fastened to the canvas of the axis K. Both axes are afterwards placed into the cistern, with their ends in the sockets FF, and the lid is put on the cistern by passing the axis through the tubes HH. The handle P is put upon the empty axis, and the pulley Q upon the axis on which the cloth is rolled, and the cord R, with the weight T, is put round it and over the pulley S. The use of the friction, produced by this weight, is to make the cloth wind tight upon the other axis. But as the effect of the weight will increase as one cylinder increases and the other lessens, Mr Rupp recommends that three or four weights be suspended on the cord, which may be taken off gradually as the person who works the machine may find it convenient. As the weights hang in open hooks, which are fastened to the

Oxy-Muriatic Acid.

the cord, it will be little or no trouble to put them on and to remove them.

Things being thus difpofed, the bleaching liquor is to be transferred from the veffels in which it has been prepared into the apparatus, by a moveable tube paffing through the tube I, and defcending to the bottom of the ciftern. This tube being connected with the veffels, by means of leaden or wooden pipes provided with cocks, hardly any vapours will efcape in the transfer. When the apparatus is filled up to the line *a*, the moveable tube is to be withdrawn, and the tube I clofed. As the liquor rifes above the edge of the rim G, and above the tubes HH, it is evident that no evaporation can take place, except where the rim does not apply clofely to the fides of the box; which will, however, form a very trifling furface if the carpenter's work be decently done. The cloth is now to be wound from the axis L upon the axis K, by turning this; and when this is accomplifhed, the handle P and pulley Q are to be changed, and the cloth is to be wound back upon the axis L. This operation is, of courfe, to be repeated as often as neceffary. It is plain, that by this procefs of winding the cloth from one axis upon the other, every part of it is expofed, in the moft complete manner, to the action of the liquor in which it is immerfed. It will be neceffary to turn, at firft, very brifkly, not only becaufe the liquor is then the ftrongeft, but alfo becaufe it requires a number of revolutions, when the axis is bare, to move a certain length of cloth in a given time, though this may be performed by a fingle revolution when the axis is filled. Experience muft teach how long the goods are to be worked; nor can any rule be given refpecting the quantity and ftrength of the liquor, in order to bleach a certain number of pieces. An intelligent workman will foon attain a fufficient knowledge of thefe points. It is hardly neceffary to obferve, that, if the liquor fhould retain any ftrength after a fet of pieces are bleached with it, it may again be employed for another fet.

With a few alterations, this apparatus might be made applicable to the bleaching of yarn. If, for inftance, the pulley O were removed from the end of the axis K, and fixed immediately under the tube H;—if it were perforated in all directions, and tapes or ftrings paffed thro' the holes, fkains of yarn might be tied to thefe tapes underneath the pulley, fo as to hang down towards the bottom of the box. The apparatus being afterwards filled with bleaching liquor, and the axis turned, the motion would caufe every thread to be acted upon by the liquor. Several axes might thus be turned in the fame box, and being connected with each other by pulleys, they might all be worked by one perfon at the fame time; and as all would turn the fame way and with the fame fpeed, the fkains could not poffibly entangle each other.

P.

Painting.

ENCAUSTIC PAINTING is an art of very high antiquity, which, after being loft for many ages, was reftored, as is commonly believed, by the celebrated Count Caylus, whofe method was greatly improved, firft by Mr Jofiah Colebrooke, and afterwards by Mifs Greenland, who brought the rudiments of her knowledge from Italy (fee ENCAUSTIC, *Encycl.*) In that country encauftic painting had employed the attention of various artifts and men of learning, fuch as Requeno, Lorgna, and Aftori, &c.; but the beft account of it that has fallen under our notice, is in that valuable mifcellany called the *Philofophical Magazine*, taken from a work of Giov. Fabbroni, publifhed at Rome in the year 1797.

According to this author, "the knowledge and ufe of encauftic painting is certainly older than the time of the Greeks and the Romans, to whom the learned Requeno feems to affign the exclufive poffeffion of this art; becaufe the Egyptians, who, with the Etrufcans, were the parents of the greater part of the inventions known among mankind, and from whom the Greeks learned fo much, were acquainted with and employed encauftic painting in the ancient ages of their greatnefs and fplendour, as is proved by the valuable fragments of the bandages and coverings of fome mummies which he had examined. No oil-painting (he fays), of only two or three hundred years old, exhibits a white paint which has kept fo well as that feen on thefe fragments; and this circumftance fufficiently proves the fuperiority of the encauftic method over the common oil painting, which, notwithftanding the general opinion, cannot, he thinks, have been unknown to the ancients.

"It is impoffible (fays he) that in Egypt and Phœnicia, where fo much ufe was made of flax, the oil procured in abundance from that plant fhould have been unknown. Thofe who have kept oil, or who have fpilt any of it, whether nut or lintfeed oil, muft have remarked that it poffeffes the property of foon drying by the effects of the atmofphere; and therefore it may be eafily believed that mankind muft foon have conceived the idea of employing it, particularly for fhips, which, as Herodotus fays, were painted with red ochre in the earlieft periods, and adorned with figures and ornaments. The ufe of oil afforded painting a much fimpler and eafier method than that of wax; it muft therefore have been firft adopted, and the tranfition from oil to wax muft be confidered as a ftep towards bringing the art to perfection; becaufe encauftic painting is not expofed to the irremediable inconveniences that arife in oil painting, the value of which we extolled through ignorance, and praifed as a new invention.

"Oil in general, and in particular drying oil which the painters ufe, has naturally a ftrong inclination to combine itfelf with the vital air or oxygen of the atmofphere, and by imbibing oxygen it becomes dry, and affumes the character of refin; but the colour then becomes darker, as is the cafe with tranfparent turpentine, which gradually becomes a black pitch.

"Accord-

"According to the new and more accurate method of decompofing bodies, oil confifts principally of hydrogen and carbon. By coming into contact with the atmofphere, and abforbing its oxygen and light, it undergoes a flow and imperceptible combuftion, which is not effentially different from the fpeedy and violent one which it would undergo in the common mode of burning. It firft paffes, by imbibing oxygen, into the ftate of a more or lefs dark refin; lofes gradually its effential hydrogen, which makes a new combination, and afterwards the oxygen itfelf which has attracted the carbon; and at length leaves behind a thin layer of actual carbon, which in the end becomes black in the courfe of time, and confiderably obfcures the oil-painting. By a continuance of the before-mentioned flow combuftion, the carbon itfelf, as it were, burns alfo: if it be ftrongly acted upon by the light, it attracts the oxygen of the atmofphere, and again brings forward the carbonic acid or fixed air, which gradually flies off. By this, which I may call the fecond degree of combuftion, the painting muft become dufty and friable, like crayon *painting*.

"Hence it appears (fays our author) that one can hope only for a tranfient or deceitful effect from the refrefhing of oil paintings with oil; becaufe the harmony of the tones, which the painter eftablifhes as fuited for the moment, does not proceed with equal fteps, and cannot preferve itfelf in the like meafure for the courfe of a few years, as each tint, as they fay, ought to increafe, or, to fpeak more properly, to burn in proportion to its antiquity. It thence follows, that mere wafhing may be prejudicial to an old painting; and that the method of refrefhing paintings, as it is called, by daubing over the furface, from time to time, with new drying oil, is highly prejudicial and ill calculated for the intended purpofe, fince the oil when it becomes dry contracts in its whole furface, carries with it the paint under it, and occafions cracks in the painting. New oil of this kind gives occafion to mineral paints to be reftored; but covers the picture with a new coat of refin, and then of carbon, which arifes from the gradual combuftion, and always caufes more blacknefs, and the decay of the painting which one wifhes to preferve.

"Wax, on the other hand, undergoes a change which is very different from that of drying oil. The wax, inftead of becoming black by the contact of the atmofphere, increafes in whitenefs, and, according to its natural quality, is not decompofed in the air, and it does not ftrongly attract the oxygen of the calces or metallic afhes which are commonly ufed in painting. Moreover, the fo-called earths, which are in themfelves white, and are never variable either by the prefence or abfence of oxygen, cannot be employed in oil-painting, becaufe that fluid makes them almoft tranfparent, and caufes them to remain as it were without body, and not to produce the wifhed-for effect. That beautiful white, which may be obferved on the before-mentioned Egyptian encauftic, is nothing elfe than a fimple earth, and, according to our author's chemical experiments, a chalk which is alfo unalterable."

That the ancients were once acquainted with the ufe of oil-painting, and neglected it on account of the great fuperiority of the encauftic method, our author thinks farther evident from the different accounts which we have of the ancient paintings. "Thus Petronius praifes the frefh appearance which the valuable works of Zeuxis and Apelles had, even in his time; but Cicero, on the other hand, fpeaks of the paintings of the ancients having fuffered from blacknefs. The former fpeaks of wax-painting, and the latter certainly alludes to paintings in oil. It is well known that paintings with wet chalks or water colours do not become black by age, and that this is the cafe alfo with encauftic. Of this any one may be convinced, not only by the expreffions of the above quoted authors, but by one's own eyes on furveying the Egyptian fragment alluded to. Galland proves, on various grounds, that a painting was made with oil fo early as the reign of Marcus Aurelius; and if no fpecimens of that period have reached us, this is perhaps to be afcribed to the frail and perifhable nature of this fpecies of painting."

Sign. Fabbroni, after fome farther obfervations, calculated to prove that metallic oxides or calces could not have been employed as pigments on fuch mummies as ftill retain their colours frefh, proceeds thus: "Thofe who are acquainted with the accuracy and certainty of the method not long fince introduced into chemical operations, will be convinced, that in 24 grains of the encauftic painting, which I ventured to detach from the above-mentioned Egyptian fragment, in order to fubject it to examination, the mixture of an hundredth part of a foreign fubftance would have been difcovered with the greateft certainty; that the refin of Requeno muft undoubtedly have been perceptible to me, and that the alkali of Bachelier and Lorgna could not have efcaped the counteracting medium. But in this Egyptian encauftic I found nothing except very pure wax, though I varied my analyfis in every known method. I muft therefore conclude, that modern learned writers, at leaft in refpect to this Egyptian mode of painting, were as far from the truth as the accounts of ancient authors appear to me precife and fatisfactory; and that the encauftum with which formerly the fore part of fhips and the walls of houfes and temples were painted, was fomething different from foap or refinous crayons.

"I am well aware that it will be afked, In what manner can wax at prefent be rendered fufficiently liquid for the ftrokes of the pencil, if it be not converted into powder or foap? This queftion, in my opinion, can be fully anfwered from the words of an ancient author, and, in the next place, by experience.

"Vitruvius in particular, book vii. chap. ix. expreffes himfelf in the following clear manner:

'Thofe (fays he) who wifh to retain cinnabar on walls, cover it, when it has been well laid on and dried, with punic wax diluted in a little oil (let this be well remarked; and after they have fpread out the wax with a hair brufh, they heat the wall by means of a brazier filled with burning coals (hence it is called encauftic painting), and then make it fmooth and level by rubbing it with wax tapers and clean cloths, as is done when marble ftatues are covered with wax. The effect of this wax cruft is, that the colour is not deftroyed by the light of the fun or the moon (A).'

"It

(A) The reader will find the original of this paffage, with a tranflation fomewhat different, in the article ENCAUSTIC, *Encycl.*

"It here appears, that the Romans, who copied the Grecian procefs, which the latter borrowed from the Egyptians, mixed the wax with an oil to make it pliable under the brufh; but no maftic, alkali, or honey, as has been ingenioufly imagined, and which fome have thought might be employed with fuccefs. The difficulty now will be confined to point out in what manner this oil was employed. It does not appear that they ufed thofe fat oils which are commonly called drying oils; becaufe they could have employed thefe as we do, without the addition of wax, which, in fuch a cafe, would have been entirely fuperfluous. Fat oils which do not dry would not have been proper for that purpofe, as they would have kept the wax continually in the ftate of a foft pomade or falve. Befides, my experiments (continues the author) would without doubt have fhewn me the exiftence of any oily matter.

"With regard to effential or volatile oils, a knowledge of them is not allowed to the ancients, as the invention of diftilling is not older than the eighth or ninth century, and therefore falls in with the period of Geber or Avicenna." Yet it is certain, that, in order to ufe wax in their encauftic painting, they muft have combined it with an ethereal volatile oil, of which no traces fhould afterwards remain; becaufe this was neceffary for the folidity of the work, and becaufe no oil was found in the fragment that was examined. But naphtha is fuch an oil, much lighter (fays our author) than ether of vitriol itfelf. It is exceedingly volatile, and evaporates without leaving a trace of it behind. On this account it is ufed when fignatures and manufcripts are to be copied; becaufe the paper, which is moiftened by it, and fo rendered tranfparent, quickly becomes white and opaque as before by the complete evaporation of the naphtha. That the Affyrians, Chaldeans, and Perfians, were well acquainted with the properties of naphtha is known to every fcholar; and hence our author thinks it highly probable that it was ufed by thofe nations to render wax fit for painting. "It appears to me (fays he) that the Greeks, as was the cafe with many other things, learned encauftic from the Egyptians, who probably derived it from the Affyrians or Chaldeans; and if fo, we have difcovered the real mixture ufed for ancient encauftic painting."

To put the matter, however, beyond a doubt, Sign. Fabbroni prepared, for an eminent Saxon painter, a folution of Venetian wax in highly purified naphtha, defiring him to mix up with it the colours neceffary for a painting. The artift complied; and both he and our author were aftonifhed, as well as all their friends, at the high tone which the colours affumed, and the agreeable luftre which the painting afterwards acquired when it had been rubbed over with a foft cloth. A fimilar folution of wax was made for another artift, in which the fpirit of turpentine was ufed inftead of naphtha with equal fuccefs. Our author therefore concludes, we think with reafon, that if he has not difcovered the real compofition employed by the ancients in their encauftic paintings, he has at leaft approached much nearer to that difcovery than any of his predeceffors who have employed their learned labours in the fame field of inveftigation.

PAINTINGS, or PICTURES, are often done upon objects from which, when they are valuable, it would be defirable to transfer them. Thus, a connoiffeur in painting might naturally wifh to transfer an old and valuable picture from the ceiling or walls of his room to ftretched canvas: and fuch a man would confider himfelf as deeply indebted to the artift who fhould perform fo arduous a tafk. This tafk has actually been performed by Mr *Robert Salmon* of Woburn, Bedfordfhire, who was honoured by the *Society for the Encouragement of Arts, &c.* with the greater filver pallet, for communicating the method by which he accomplifhed it.

"The firft thing (fays Mr Salmon) to be attended to with refpect to paintings, either on plaftered walls or ceilings, or on boards, is, that the place in which they are be fecure from wet or damp. If the paintings are on old walls in large buildings, or other places where this cannot be attained by art, then the fummer feafon fhould be taken for the purpofe, as the picture will rarely efcape damage, if wet or damp gets at it while under the procefs. At the fame time, care fhould be taken that the room, or other place, be not overheated; as that would produce equally bad effects.

"Thefe precautions being taken, the next thing is to examine the furface of the painting. If there are any holes in the fame, they muft be carefully filled up with a pafte or putty, made of glue and whiting: this, if the holes are large, fhould be twice or thrice done, fo as entirely to fill them up, and leave the furface even and fmooth; but if there are any bruifed places, with paint ftill remaining on the furface of the bruifed parts, then this ftopping muft not be applied, but the fecuring-canvas, hereafter defcribed, muft be preffed down into thefe places. In the places that are ftopped, there will of courfe appear blemifhes when the picture is transferred; but the procefs is rendered much more certain and fure by being fo done. Attention muft next be paid to lay down any blifters, or places where the paint is leaving the ground: this is done by introducing, between the paint and the ground, fome very ftrong pafte of flour and water; and the furface of the bliftered paint being damped with a wet fponge or brufh, it may be preffed with the hand home to the ground, to which it will then adhere.

"All the unfound places being thus fecured, care muft be taken to clear the furface of any greafe or dirt, as alfo of any particles of the pafte that may happen to be left on it. The next thing is, to determine the fize of the painting meant to be taken off: If it is on a plain furface, a board of the fize of the picture muft be procured, not lefs than an inch in thicknefs, and framed together with well feafoned wood, in fmall pannels, fmooth and flufh on one fide. This done, a piece of fine open canvas muft be provided, fuch as the fineft fort ufed for hanging paper on; which canvas is to be fomewhat larger than the picture, and fo fewed together, and the feam fo preffed, that it be perfectly fmooth and even. This is what Mr Salmon calls the fecuring canvas; which, being fo prepared, is to be ftuck on the furface of the picture with a pafte made of ftrong beer, boiled till it is half reduced, and then mixed with a fufficient quantity of flour to give it a very ftrong confiftence. To large pictures on walls or ceilings, the canvas muft for fome time be preffed, and rubbed with the hand as fmooth as poffible, working it from the middle to the outfide, fo as to make it tolerably tight; obferving, as it dries, to prefs it, with the hand or cloth, into any hollow or bruifed places, fo that

that it may adhere to every part of the painting: this done, it is left to dry; which it will generally do in a day or two When dry, a fecond canvas, of a ftronger and clofer fort, and of the fame fize as the other, is in like manner to be attached on the top of the firft. This laft will want very little attention, as it will readily adhere to the firft; and, being dry, attention muft be paid to take off any fmall knots or unevennefs that may be upon the furface of it; which done, the whole fhould be again covered with a thin pafte of fize and whiting; which is to be pumiced over when dry, fo as to make the whole perfectly fmooth and even.

"The painting being thus fecured, the board, already prepared to the fize of the picture, is to be put with the fmooth fide againft the furface thereof, fo as exactly to cover as much as is intended to be transferred. The edges of the canvas, which, as is before directed, is to be larger than the painting, are then to be pulled tight over, and clofely nailed to the edge of the board. If the painting is large, and either on a ceiling or wall, the board muft, by proper fupports, be firmly fixed againft it, fo that it can readily be lowered down when the plafter and painting are detached.

"The canvas and board being fixed, the painting is to be freed from the wall or ceiling, together with a certain portion of the plaftering: this, with proper care and attention, may be readily done. If on a ceiling, the firft thing is to make fome holes through the plaftering, round the outfide of the board and painting; and, with a fmall faw, to faw the plaftering from one hole to another, till the whole is difunited from the other parts of the ceiling: this done, the workman muft get at the upper fide of the ceiling, where he muft free the plaftering from the laths, by breaking off the keys thereof, and with a chifel cut out the laths; whereby the plaftering, together with the picture, will be left refting on the board and fupports.

"If the painting is on a brick or ftone wall, the wall muft be cut away at top, and down the fides of the painting; and then, by means of chifels or faws in wooden handles, of different lengths, the wall muft be cut away quite behind the painting; leaving the fame, together with the plaftering, refting on the board. This operation may fometimes be done with a faw: or, if the wall be not thick, nor the other fide of much confequence, the bricks or ftones may be taken out from that fide, leaving the plaftering and painting as before. This laft method (fays the author) I have not practifed: the other, of cutting away fome part of the wall, I have, and fee no difficulty, or very great labour, in the operation; but that, of courfe, muft be various, according to the texture of the wall and mortar.

"If the paintings are on curved furfaces, fuch as the coves of ceilings, then the only difference of operation is, that fome ribs of wood muft be cut out, and boarded fmooth to the curve of the furface of the painting, and then fixed up thereto, in place of the before defcribed bearing-board; the painting is then to be freed, and left with the plaftering, refting on the bearers.

"For paintings on wainfcot or boards, the fame fecuring and procefs is to be exactly followed; only that, as the wainfcot or board can always be cut to the fize wanted, and laid horizontal, the fecuring-canvas is to be ftretched thereon, and turned over the edges of the fame till it is dry; after which, the edges are again to be turned up, and nailed to the board, in the fame manner as with refpect to paintings from walls.

"Having, as before defcribed, in any of the aforementioned cafes, freed the paintings from their original places, you have got them fecured to two thickneffes of canvas, with their furfaces on the board prepared for that purpofe; this being the cafe, they can readily be removed to any room or fhop, to be finifhed as follows: Having carried the painting into the fhop or room, which fhould be moderately warm and dry, but by no means overheated, lay the board on a bench or treffels, fo that the back of the picture be uppermoft: the plaftering or wood, as may happen, is then to be cleared away, leaving nothing but the body of paint, which will be firmly attached to the fecuring-canvas. To perform this, a large rafp, a narrow plane, and chifels, will be requifite. This operation, though difficult to be defcribed, would foon be learned by any one who fhould make the attempt; nor is it very tedious; and being performed, the picture is ready to be attached to its new canvas, as follows.

"The painting being cleared, and lying on the board, the back thereof is to be painted three or four times over fucceffively, with any good ftrong-bodied paint; leaving one coat to dry before another comes on: a day or two between each will generally be found fufficient. Each of thefe coats, and particularly the firft, fhould be laid on with great care, taking but a fmall quantity in the brufh at a time, and laying it very thin. This precaution is neceffary, to prevent any of the oil or paint from paffing through any fmall cracks or holes in the furface of the picture; as fuch oil or paint would run into the pafte, and fo attach the fecuring-canvas to the picture, as to prevent its being afterwards got off. If any fuch holes or cracks are obferved, they fhould be ftopped up with the glue and whiting pafte, and the painting then repeated, till a complete coat is formed on the back of the picture. It is then ready for attaching to its canvas. which is done by fpreading all over the picture a pafte made of copal varnifh, mixed with ftiff white lead, and a fmall quantity of any other old fat paint; all which being fpread equally over with a pallet-knife, fuch a canvas as the firft fecuring-canvas is laid thereon, and ftrained and nailed round the edges of the board; in which ftate it is left till it becomes tolerably dry: then a fecond canvas, of a ftronger fort, muft be in like manner attached on the firft, and left till it is perfectly dry and hard. This generally takes about two months; and the longer the painting is left, the more fecurely it will be attached to its canvas, and lefs liable to crack or fly therefrom. When fufficiently dry, all the four canvaffes are to be unnailed from the board, and the edges turned up the reverfe way, and nailed to a proper ftretching-frame. This is done by unnailing from the board a part on each fide at a time, and immediately nailing it to the ftretching-frame, fo as never to leave the canvas to crack or partially ftretch, which would damage the picture In this manner, by degrees, the cloths are entirely detached from the board, and firmly fixed on the ftretching-frame. The fuperfluous canvas, left larger than the frame, may then be cut off, and the wedges put in the frame, and moderately tightened up. There remains then only to clear the furface of the painting from the fecuring-canvas: which is done by repeatedly wafhing the furface with

with a fponge and moderately warm water. In doing this, no violence or force muft be ufed; and, by frequent and gentle wafhings, the pafte will all be worked out with the fponge. The edges of the outer canvas are then to be cut round, and ftripped off: the other, next the furface of the picture, is to be ferved in like manner; which done, nothing remains but to take the pafte clean off, and repair any defects: the picture will then be as ftrong as if painted on the canvas.

"For taking pictures off walls, without taking the walls down, or cutting away more thereof than the plaftering, the following procefs is propofed:

"The furface of the picture is to be firft fecured, in the manner before defcribed; but inftead of the plain board, a bearer fhould be prepared with a convex furface, compofed of ribs, boarded over, fo as to form part of a cylinder, of not lefs than five feet radius, and as long as the height of the picture. This bearer being prepared, in order to apply it, a floor or platform fhould be erected, and placed horizontally, with its furface level, and its edge immediately in contact with the bottom of the picture meant to be transferred. The ufe of this platform is for the above-defcribed bearer to reft and move upon; which bearer fhould be fet on its end, with one edge in contact with the wall, at one fide of the picture; confequently the other edge will be at fome diftance from the wall, according to the fize of the picture and convexity of the bearer. Being thus placed, the fuperfluous edge of the fecuring-canvas fhould be turned over, and nailed to that edge of the bearer that is next the wall: This done, the operation of cutting away the plaftering fhould be begun; which may be done with the corner and end of a fhort faw; fawing between the brick-work and plaftering, and leaving the thicknefs, or part of the thicknefs, of the plaftering on the painting faftened to the bearer. When this edge of the picture is freed, the whole height, for nine or ten inches under the edge of the bearer that is fartheft from the wall, muft then be gently forced nearer; confequently the other edge, together with the painting and plafter that is freed, will leave the wall, and give an opportunity of introducing the faw behind, and cutting away the fame to a certain diftance farther under; and, by repeating this, the whole of the picture will at length be freed, and left on the bearer. Each time the bearer is removed, and, as it were, rolled on the vertical furface of the wall, care muft be taken to turn and nail the fecuring-canvas on the top and bottom edges of the bearer, fo as to fecure the freed plaftering and picture from moving about; and, laftly, before the bearer and plaftering be moved, to nail the other edge of the picture in the fame way, which will fecure the whole to the bearer. This done, the picture and bearer are at liberty to be moved to a proper place, in order to be freed from the remaining plafter. The edges may then be unnailed; the painting and canvas flipped from this bearer on to a plain board; and the new canvas may be then put on; which is to remain till dry, as in other cafes.

"It may appear, that the bending of the canvas and plaftering to the convex bearer will crack the plafter, and damage the painting; but, from experience (fays Mr Salmon) I have obferved, that, to a curve of fuch or even lefs radius, plaftering will bend, without any vifible crack, even on the exterior part thereof; and that part next the bearer, not having occafion, in bending, to extend its parts, will confequently be much lefs liable to be difturbed by fuch bending."

In clearing the wood from the paintings, our author never made ufe of aquafortis, or any other liquid; the ufe of which he conceives would be very tedious, and attended with danger, left it fhould get through the paint, and wet or damp the pafte by which the fecuring canvas is fixed. In working off the wood, he generally made ufe of fuch planes as by the joiners are called the *levelled rabbit-plane*, and *fmall rounds*. By the corners of the former, and proper handling of the latter, the wood is cleared off without force or violence: even the fmalleft particles may, in general, be got off; although in fome paintings, and in particular parts of others, he has met with places on which he thought it beft to leave fome particles, or fine fplinters, of wood, but nothing more. Rafps, and fometimes a fine chifel, are ufeful, to clear off fuch parts as may be in hollow places, or where particles of wood are left, as above. The time required will be various, according to the manner in which the painting was originally done; fome being painted on boards previoufly prepared with a water colour; others immediately painted with oil on the wood. This laft fort is by much the moft difficult; the other is more eafy, as the previous preparation prevents the wood from imbibing the oil, and confequently admits it to be more eafily feparated.

PALILICUM, the fame as Aldebaran, a fixed ftar of the firft magnitude, in the eye of the bull, or fign Taurus.

PALLIFICATION, or Piling, in architecture, denotes the piling of the ground-work, or the ftrengthening it with piles, or timber driven into the ground; which is practifed when buildings are erected upon a moift or marfhy foil.

PALM, an ancient long meafure, taken from the extent of the hand. See Palmus, *Encycl.*

PALMÆ, palms. See *Encyclopædia*. The fubject is introduced here to notice a kind of palm, the product of North America, of which we have the following account by Dr Barton.

"There grows upon the river Mobile a fpecies of palm, which is but little known to naturalifts, but which promifes to be an important article of food to man. It has no ftalk or ftem above ground. The leaves fpread regularly all round, and when fully expanded are flabelliform. In the centre of thefe leaves is produced the receptacle of the fruit, which is of the form and fize of a common fugar-loaf. This receptacle confifts of a vaft number of drupes, or berries, of the fize and fhape of common plums: each is covered with a fibrous, farinaceous, pulpy coating, of confiderable thicknefs. This fubftance is faid to refemble manna in texture, colour, and tafte; or, perhaps, it ftill more refembles moift brown fugar, with particles of loaf-fugar mixed with it. It is a moft delicious and nourifhing food, and is diligently fought after in the places where it grows. Upon firft tafting it, it is fomewhat bitter and pungent.

PANORAMA, a word derived from παν and ὁραμα; and therefore employed of late to denote a painting, whether in oil or water colours, which reprefents an entire view of any country, city, or other natural objects, as they appear to a perfon ftanding in any fituation, and turning quite round. To produce this effect, the

Panorama, Paper.

the painter or drawer muſt fix his ſtation, and delineate correctly and connectedly every object which preſents itſelf to his view as he turns round, concluding his drawing by a connection with where he began. He muſt obſerve the lights and ſhadows, how they fall, and perfect his piece to the beſt of his abilities. There muſt be a circular building or framing erected, on which this drawing or painting may be performed; or the ſame may be done on canvas, or other materials, and fixed or ſuſpended on the ſame building or framing, to anſwer the purpoſe complete. It muſt be lighted entirely from the top, either by a glazed dome, or otherwiſe as the artiſt may think proper. There muſt be an incloſure within the ſaid circular building or framing, which ſhall prevent an obſerver going too near the drawing or painting, ſo as it may, from all parts it can be viewed, have its proper effect. This incloſure may repreſent a room, or platform, or any other ſituation, and may be of any form thought moſt convenient; but the circular form is particularly recommended. Of whatever extent this inſide incloſure may be, there muſt be over it (ſupported from the bottom, or ſuſpended from the top) a ſhade or roof; which, in all directions, ſhould project ſo far beyond this incloſure, as to prevent an obſerver from ſeeing above the drawing or painting when looking up; and there muſt be without this incloſure another interception, to repreſent a wall, paling, or other interception, as the natural objects repreſented, or fancy, may direct, ſo as effectually to prevent the obſerver from ſeeing below the bottom of the drawing or painting; by means of which interception, nothing can be ſeen on the outer circle but the drawing or painting intended to repreſent nature. The entrance to the inner incloſure muſt be from below, a proper building or framing being erected for that purpoſe, ſo that no door or other interruption may diſturb the circle on which the view is to be repreſented. And there ſhould be, below the painting or drawing, proper ventilators fixed, ſo as to render a current circulation of air through the whole: and the inner incloſure may be elevated, at the will of an artiſt, ſo as to make obſervers, on whatever ſituation he may wiſh they ſhould imagine themſelves, feel as if really on the very ſpot.

PAPER is an article of ſuch importance, and at preſent * of ſo enormous a price, that no improvement in its manufacture ſhould paſs unnoticed in a work of this nature. The diſcovery made in France by M. Bertholet of the efficacy of oxy-muriatic acid in expediting the proceſs of Bleaching (ſee that article in this *Suppl.*), has contributed eſſentially to facilitate the manufactures, not only of cotton and linen cloths, but alſo of paper, of which it has even increaſed the materials. Formerly writing paper could be made of *unprinted* linen alone; but by means of the proceſs of M. Bertholet even printed linen may be made into the fineſt and whiteſt paper. In the year 1795 a patent was granted to Mr Elias Carpenter of Bermondſay, Surrey, for a method of bleaching paper of ſuch materials in the *water-leaf* or *ſheet*, and ſizing it without drying.

* 1800.

In the preparation of the pulp, the coarſer rags are to be macerated for two or three days in a cauſtic alkaline ley, and wrought into ſheets of paper in the uſual way; a ſtrong wooden box or trough is then to be procured, of a ſize proportioned to that of the paper, lined on the inſide with white paint, and furniſhed with ſeveral ſtages of croſs bars of glaſs: the bottom of the box is to be covered with a ſtratum about one inch deep of cauſtic ley, and the paper laid by quarter reams, or leſs, acroſs the glaſs bar. A hole muſt be made in the box to admit the beak of an earthen-ware retort, into which muſt be put manganeſe and ſea ſalt, in powder, ſulphuric acid, and an equal quantity of water impregnated with the ſteams of burning ſulphur (ſulphureous acid). The cover of the box is to be made air-tight by luting or ſlips of paper dipped in paſte. The apparatus being thus prepared, the belly of the retort is to be plunged in water, kept boiling, and in a ſhort time the oxy-muriatic gas will be driven into the box, will penetrate the paper, and render it of a dazzling whiteneſs, while the alkaline ley at the bottom will, by gradually abſorbing it, prevent its becoming ſo concentrated as to deſtroy or injure the texture of the paper. From three to four pounds of ſulphuric acid will ſuffice for one hundred weight of paper, and the operation will be completed in about eight hours. The ſheets as they are taken out of the box are to be ſized with the following mixture:

To 1 cwt. of clippings of ſkin add 14 lb. of alum, 7 of calcined vitriol, and 1lb. of gum arabic, with a ſufficient quantity of water to ſize 50 reams of fools-cap.

The ſame method will ſerve equally well to clean engravings or printing; for though the oxy-muriac acid diſcharges all ſtains, dirt, &c. yet it is incapable of acting on printers ink.

This, however, is not the only improvement in the manufacture of paper derived from modern chemiſtry. In Crell's *Chemical Annals* for the year 1797, we have an account of ſome curious experiments made by M. L. Brugnatelli, with the view of rendering

Paper incombuſtible, and the writing on it, of courſe, indeſtructible by fire. Of all the ſubſtances which he tried, he found the liquor of flints the moſt proper to ſecure paper from deſtruction by fire. He dipped a ſheet of paper ſeveral times in the above liquor freſh made, or daubed it ſeveral times over the whole paper with a hair bruſh, and dried it in the ſun or in an ovan. Paper prepared in this manner loſt ſome of its ſoftneſs, became a little rougher than before, and acquired a lixivious cauſtic taſte. In other reſpects it was not different from common white paper. When this paper was laid upon glowing coals, it did not burn like common paper, but became red, and was converted to a coal, which however did not fall into aſhes like the coal of common paper, ſo that it might therefore be conſidered as petrified paper. This coal, however, is exceedingly friable; for when it is taken between the fingers, or preſſed together in any manner whatever, it drops to pieces. Still the diſcovery muſt be a valuable one, if there be any kind of ink of ſuch a nature as that the characters written with it continue viſible on this coal. Such an ink M. Brugnatelli made by combining diſſolved nitrite of zinc with common ink; and found, that the colour of this mixture, though it appeared ſomewhat pale on common paper, became ſo dark on prepared paper, that words written with it appeared more conſpicuous than words written with common ink. When the paper was burnt, or reduced to a coal, thoſe characters were ſo viſible, in a clear *white* colour on a *dark* ground, that they could be read with as much eaſe as characters written with the beſt ink on white

white paper. If the ingenious author fucceed in his attempts to difcover a method of rendering his prepared paper lefs friable when burnt, his difcovery will be one of the moft important of the prefent age.

PARABOLIC Conoid, is a folid generated by the rotation of a parabola about its axis. This folid is equal to half its circumfcribed cylinder; and therefore if the bafe be multiplied by the height, half the product will be the folid content.

Parabolic Pyramidoid, is a folid figure, thus named by Dr Wallis from its genefis or formation, which is thus: Let all the fquares of the ordinates of a parabola be conceived to be fo placed, that the axis fhall pafs perpendicularly through all their centres; then the aggregate of all thefe planes will form the parabolic pyramidoid. This figure is equal to half its circumfcribed parrallelopipedon. And therefore the folid content is found by multiplying the bafe by the altitude, and taking half the product; or the one of thefe by half the other.

Parabolic fpace, is the fpace or area included by the curve line and bafe or double ordinate of the parabola.

Parabolic Spindle, is a folid figure conceived to be formed by the rotation of a parabola about its bafe or double ordinate.

Parabolic Spiral, is a curve arifing from the fuppofition that the common or Apollonian parabola is bent or twifted till the axis come into the periphery of a circle, the ordinates ftill retaining their places and perpendicular pofitions with refpect to the circle, all thefe lines ftill remaining in the fame place. This figure is fometimes called the *Helecoid parabola*.

PARABOLOIDES, parabolas of the higher orders. The equation for all curves of this kind being $a^{m-n} x^n = y^m$, the proportion of the area of any one to the complement of it to the circumfcribing parallelogram, will be as m to n.

PARACENTRIC Motion, denotes the fpace by which a revolving planet approaches nearer to, or recedes farther from, the fun, or centre of attraction.

Paracentric Solicitation of Gravity, is the fame as the vis centripeta.

PARACHUTE, a kind of large and ftrong umbrella, contrived to break a perfon's fall from an air-balloon, fhould any accident happen to the balloon at a high elevation. This contrivance was firft thought of by Blanchard, who at different times, by means of the parachute, let fall from his balloon dogs and other animals. He ventured even to defcend in this manner himfelf; but, whether from the bad conftruction of his parachute, or from falling among trees, he had the misfortune to break one of his legs. Citizen Garnerin, as he choofes to be called, was more fuccefsful. On the 21ft of October 1797, he afcended from the garden de Mauffeux at half paft five in the evening; between the balloon and the car, in which he fat, was placed the parachute, half opened, and forming a kind of tent over the aerial traveller; and when the whole apparatus was at a confiderable height, he feparated the parachute and car from the balloon. The parachute unfolding itfelf, was, by his weight and that of the car, drawn of courfe towards the earth. Its fall was at firft flow and vertical; but foon afterwards it exhibited a kind of balancing or vibration, and a rotation gradually increafing, which might be compared with that of a leaf falling from a tree. The aëronaut, however, reached the ground unhurt.

This parachute was of cloth, and its diameter, when unfolded, about twenty-five feet. To ufe fuch inftruments with fuccefs, it is neceffary that the car be fufpended at a confiderable diftance from the parachute, fo as that the centre of gravity of the whole fhall be vertically below the centre of refiftance made by the air to the defcent of the parachute; for if the car be otherwife placed, it is evident that the parachute will incline to one fide, defcend obliquely, ofcillate, and the fmalleft irregularity in its figure will caufe it to turn round its vertical axis.

PARAGUATAN, a kind of wood which grows in Guiana, and promifes to be of great utility as a dye ftuff. We have feen no botanical defcription of the tree; but from the report made to the Council of Trade and Mines, by D. Dominique Garcia Fernandez, infpector of coinage, we learn that its bark, boiled in water, affords a coloured extract which refifts the agency of acids for a longer time than brazil or logwood; that the colour may be revived by means of alkalies, after it has been deftroyed by combination with acids; that vinegar, lemon juice, and tartar, render this colour more brilliant, while they entirely deftroy the colours of brazil and logwood; that the fecula of the bark of paraguatan fixes and attaches itfelf to wool, cotton, and filk; and that the colour is brighter on filk than on wool, and brighter on wool than on cotton. The fame fecula dried is afterwards foluble in alcohol, to which it communicates a tinge fimilar to that afforded by cochineal; but it muft be confeffed, that the colour obtained from paraguatan has not the force of that of cochineal, though it is fuperior to thofe of madder, brazil wood, and logwood. From thefe facts D. Fernandez confiders the paraguatan as one of the moft valuable productions which America furnifhes to Spain.

PARALLAX (fee *Encycl.*) is ufed, not only in aftronomy, but alfo in levelling, for the angle contained between the line of true level, and that of apparent level. And, in other branches of fcience, for the difference between the true and apparent places.

PARALLEL Ruler, is a mathematical inftrument, confifting of two equal rulers, either of wood or metal, connected together by two flender crofs bars or blades of equal length, moveable about the points of junction with the rulers. There are other forms of the inftrument; fome, for inftance, having the two blades croffing in the middle, and fixed only at one end of them, the other two ends fliding in grooves along the two rulers, &c.

The ufe of this inftrument is obvious. For the edge of one of the rulers being applied to any line, the other opened to any extent will be always parallel to the former; and confequently any parallels to this may be drawn by the edge of the ruler, opened to any extent.

PARALLELS, or Places of Arms, in a fiege, are deep trenches, 15 or 18 feet wide, joining the feveral attacks together; and ferving to place the guard of the trenches in, to be at hand to fupport the workmen when attacked. There are ufually three in an attack: the firft is about 600 yards from the covert-way, the fecond between 3 and 400, and the third near or on the

the glacis. It is ſaid they were firſt invented or uſed by Vauban.

PARALLELISM OF THE EARTH's AXIS, is that invariable ſituation of the axis, in the progreſs of the earth thro' the annual orbit, by which it always keeps parallel to itſelf; ſo that if a line be drawn parallel to its axis, while in any one poſition, the axis, in all other poſitions or parts of the orbit, will always be parallel to the ſame line.

PARAMETER, a certain conſtant right line in each of the three conic ſections; otherwiſe called alſo *latus rectum*.

PARAMARIBO, the capital of the Dutch ſettlement at Surinam, is ſituated on the right ſide of the beautiful river Surinam, at about 16 or 18 miles diſtance from its month. It is built upon a kind of gravelly rock, which is level with the reſt of the country, in the form of an oblong ſquare; its length is about a mile and a half, and its breadth about half as much. All the ſtreets, which are perfectly ſtraight, are lined with orange, ſhaddock, tamarind, and lemon trees, which appear in everlaſting bloom; while, at the ſame time, their branches are weighed down with the richeſt cluſters of odoriferous fruit. Neither ſtone nor brick is made uſe of here for pavement; the whole being one continued gravel, not inferior to the fineſt garden walks in England, and ſtrewed on the ſurface with ſea-ſhells. The houſes, which are moſtly of two and ſome of three ſtories high, are all built of fine timber, a very few excepted; moſt of the foundations are of brick, and they are roofed with thin ſplit boards, called *ſhingles*, inſtead of ſlates or tiles. Windows are very ſeldom ſeen in this country, glaſs being inconvenient on account of the heat; inſtead of which they uſe gauze frames: ſome have only the ſhutters, which are kept open from ſix o'clock in the morning until ſix at night. As for chimneys, there are none in the colony; no fires being lighted except in the kitchens, which are always built at ſome diſtance from the dwelling-houſe, where the victuals are dreſſed upon the floor, and the ſmoke let out by a hole made in the roof: theſe timber houſes are, however, very dear in Surinam, one of them having coſt above L. 15,000 ſterling. There is no ſpring water to be met with in Paramaribo; moſt houſes have wells dug in the rock, which afford but a brackiſh kind of beverage, only uſed for the negroes, cattle, &c. and the Europeans have reſervoirs or ciſterns, in which they preſerve rain water for their own conſumption; thoſe of nicer taſte let it firſt drop through a filtering-ſtone into large jars or earthen pots, made by the native Indians on purpoſe, which they barter at Paramaribo for other commodities. The inhabitants of this country, of every denomination, ſleep in hammocks, the negro ſlaves excepted, who moſtly lie on the ground: the hammocks uſed by thoſe in ſuperior ſtations are made of cotton, ornamented with rich fringe; theſe are alſo made by the Indians, and ſometimes worth above twenty guineas; neither bedding nor covering is neceſſary, except an awning to keep off the muſquitoes. Some people indeed lie on bedſteads; in that caſe they are ſurrounded, inſtead of curtains, with gauze pavilions, which admit the air freely, and at the ſame time keep off the ſmalleſt inſect. The houſes in general at Paramaribo are elegantly furniſhed with paintings, gilding, cryſtal chandeliers, china jars, &c.; the rooms are never papered or plaſtered, but beautifully wainſcotted with cedar, and Brazil, and mahogany wood.

The number of buildings in Paramaribo is computed at about 1400, of which the principal is the governor's palace, whence there is a private paſſage through the garden which communicates with Fort Zelandia. This houſe, and that of the commandant, which has lately been burnt, were the only brick buildings in the colony. The town-hall is an elegant new building, and covered with tiles; here the different courts are held, and underneath are the priſons for European delinquents, the military excepted, who are confined in the citadel of Fort Zelandia. The Proteſtant church, where divine worſhip is performed both in French and Low Dutch, has a ſmall ſpire with a clock; beſides which there is a Lutheran chapel, and two elegant Jewiſh ſynagogues, one German the other Portugueſe. Here is alſo a large hoſpital for the garriſon, and this manſion is never empty. The military ſtores are kept in the fortreſs, where the ſociety ſoldiers are alſo lodged in barracks, with proper apartments for ſome officers. The town of Paramaribo has a noble road for ſhipping, the river before the town being above a mile in breadth, and containing ſometimes above 100 veſſels of burden, moored within a piſtol-ſhot of the ſhore. Before Holland became a province of France, and thereby loſt her trade, there were ſeldom fewer than 80 ſhips at Paramaribo, loading coffee, ſugar, cocoa, cotton, and indigo, for the mother country, including alſo the Guinea men that brings ſlaves from Africa, and the North American and Leeward Iſland veſſels, which bring flour, beef, pork, ſpirits, herrings, and mackarel ſalted, ſpermaceti candles, horſes, and lumber; for which they receive chiefly molaſſes to be diſtilled into rum. This town is not fortified, but is bounded by the river on the ſouth-eaſt; by a large ſavannah on the weſt; by an impenetrable wood on the north-eaſt; and is protected by Fort Zelandia on the eaſt. This citadel is only ſeparated from the town by a large eſplanade, where the troops parade occaſionally. The fort is a regular pentagon, with one gate fronting Paramaribo, and two baſtions which command the river; it is very ſmall but ſtrong, being made of rock or hewn ſtones, ſurrounded by a broad foſſe well ſupplied with water, beſides ſome outworks. On the eaſt ſide fronting the river, is a battery of 21 pieces of cannon. On one of the baſtions is a bell, which is ſtruck with a hammer by the centinel, who is directed by an hour-glaſs. On the other is planted a large enſign-ſtaff, upon which a flag is hoiſted upon the approach of ſhips of war, or on public rejoicing days. The walls are ſix feet thick, with embraſures, but no parapet.

Paramaribo is a very lively place, the ſtreets being generally crowded with planters, ſailors, ſoldiers, Jews, Indians, and Negroes, while the river is covered with canoes, barges, &c. conſtantly paſſing and repaſſing like the wherries on the Thames, often accompanied with bands of muſic; the ſhipping alſo in the road adorned with their different flags, guns firing, &c. not to mention the many groupes of boys and girls playing in the water, altogether form a pleaſing appearance; and ſuch gaiety and variety of objects ſerve, in ſome meaſure, to compenſate for the many inconveniences of the climate. Their carriages and dreſs are truly magnificent; ſilk embroidery, Genoa velvets, diamonds, gold and ſilver lace, Paramaribo, Paris.

lace, being daily worn, and even the mafters of trading fhips appear with buttons and buckles of folid gold. They are equally expenfive at their tables, where every thing that can be called delicate is produced at any price, and ferved up in plate and china of the neweft fafhion, and moft exquifite workmanfhip. But nothing difplays the luxury of the inhabitants of Surinam more than the number of flaves by whom they are attended, often twenty or thirty in one family. White fervants are feldom to be met with in this colony.

The current money are ftamped cards of different value, from five fhillings to fifty pounds: gold and filver is fo fcarce, that the exchange premium for fpecie is often above 10 *per cent.* A bafe Dantzic coin called a *bit*, value fomething lefs than fixpence, is alfo current in Surinam. English and Portuguefe coin are fometimes met with, but moftly ufed as ornaments by the Mulatto, Samboe, Quaderoon, and Negro girls. The Negro flaves never receive any paper money; for as they cannot read, they do not underftand its value; befides, in their hands, it would be liable to many accidents, from fire or children, and particularly from the rats, when it becomes a little greafy.

This town is well fupplied with provifions, *viz.* butchers meat, fowls, fifh, and venifon. Vegetables in particular the country abounds with; befides the luxuries peculiar to this climate, they import whatever Europe, Africa, and Afia can afford. Provifions, however, are exceffively dear in general, efpecially thofe imported, which are moftly fold by the Jews and mafters of fhips. The firft enjoy extraordinary privileges in this colony; the latter erect temporary warehoufes for the purpofe of trade, during the time their fhips are loading with the productions of the climate. Wheat flour is fold from four-pence to one fhilling per pound; butter, two fhillings; butcher's meat never under one fhilling, and often at one fhilling and fixpence; ducks and fowls from three to four fhillings a couple. A fingle turkey has fometimes coft one guinea and a half; eggs are fold at the rate of five, and European potatoes twelve, for fixpence. Wine three fhillings a bottle. Jamaica rum a crown a gallon. Fifh and vegetables are cheap, and fruit almoft for nothing.

PARIS (Francis), a man more famous after his death than during his life, by the miracles which were faid to be performed at his tomb. He is generally known by the name of Abbé Paris; and his pretended miracles, with others of like manufacture, have furnifhed deiftical writers, and Mr Hume in particular, with a kind of argument againft the reality of the miracles of which we have an account in the Gofpel. It is merely that we may ftate his pretenfions fairly, that we have introduced him to the notice of our readers; for in every other refpect he is wholly unworthy of their regard. He was the fon of a counfellor in Parliament, and had the profpect, if he had chofen it, of fucceeding to his father's appointment; but he chofe rather to become an ecclefiaftic, and he became a very zealous one. He gave up all his poffeffions to his brother, refufed preferment intended for him by the cardinal de Noailles, devoted himfelf entirely to retirement, and made ftockings for his own fupport, and for the affiftance of the poor. He died perhaps in confequence of his rigorous mode of life, May 1. 1727, at the age of only 37. His brother raifed a monument to him in the fmall churchyard of St Medard, to which the poor and the pious foon began to flock; and after a time it was reported, that in confequence of their prayers at that tomb, fome fick perfons had received cures. As Paris had been a rigorous Janfenift, this was a fine opportunity for that fect to gain credit to their caufe; the miracles were therefore multiplied, and a variety of perfons affected the moft fingular convulfions.

Paris.

The minds of the people becoming inflamed by thefe extravagancies, the court found it neceffary to fhut up the churchyard, which was done on the 27th of January 1732. On this occafion, fome profane wit wrote upon the wall of the place,

> De par le Roy, defenfe a Dieu,
> De faire miracles en ce lieu.

The convulfions were continued, for a little while, in private houfes, but by degrees the matter fubfided, and the Abbé Paris was forgotten.

The diftinction between miracles, exhibited to ferve a party, and attefted only by thofe who are zealous in its fupport, and miracles performed in the fight of unbelievers, who, in fpite of their deep-rooted prejudices, were converted by them, is too ftriking to be overlooked by any, but thofe who are defirous of drawing a falfe and impious parallel; yet has Mr Hume dared to reprefent the miracles performed at the tomb of this faint as outvying in number, nature, and evidence, the miracles of Chrift and his apoftles—with what truth, the following obfervations will fhew:

1ft, It was often objected by the enemies of the faint, and the objection was never confuted by his friends, that the *proftrations* at his fepulchre, like animal magnetifm more lately, *produced* more difeafes than they *cured*. Such, furely, was not the nature of our Saviour's miracles.

2dly, Though the crowds of fick and infirm perfons who flocked to the tomb for relief were, by all accounts, innumerable; yet all the cures, of which the zealous hiftorian of the Miracles could procure vouchers, amounted only to NINE! Now, were thoufands, and ten thoufands of difeafed perfons to apply to fome circumforaneous quack, in full affurance of his extraordinary abilities and fkill in phyfic, could it furprife any perfon, if the diftempers of *eight* or *nine* of them fhould take a favourable turn while they were under a courfe of his ufelefs medicines?

3dly, We do not read that of thofe nine who were cured by the dead Abbé, the greater part were Jefuits and enemies to the Janfenifts; whereas the greater part of our Saviour's miracles were performed upon unconverted Jews, and one of them upon the fervant of the high prieft, who was thirfting for his blood.

4thly, The cures reported to have been performed at the grave of Paris were all fuch as might have been accomplifhed by natural means. Thus, a Spaniard who had loft one eye, and was diftreffed with an inflammation in the other, had the inflamed eye gradually cured, but not the loft eye reftored. Another perfon having pricked his eye with an awl, loft the fight of it in confequence of the aqueous humour dropping out; but his fight was reftored *whilft* he was paying his devotions to the Abbé—and fo it would have been while he was curfing the Abbé, had he continued his execrations for a fufficient length of time.

Paris, Parkhurst.

5*thly*, None of the cures said to have been performed were *instantaneous*. *All* the worshippers at the tomb persisted for *days*, several of them for *weeks*, and some for *months*, daily imploring the intercession of the Abbé *before* they received relief from their complaints.

6*thly*, Most of the devotees had been using *medicines* before they applied to the saint, and continued to use them *during the whole time* of their application; whilst it is confessed that the distempers of others had *abated* before they determined to solicit his help.

7*thly*, Some of the cures attested were *incomplete*, and only of a temporary duration. Thus, the Spaniard was relieved only from the most inconsiderable part of his complaint, and that too but for a very short period; for soon after his return home he relapsed into his former malady, as was fully attested by certificates and letters from Madrid. All this has been completely proved by the Archbishop of Sens; who in his *Pastoral Instruction*, published at the time the miracles were making a noise, has,

8*thly*, Clearly detected the deceit and little artifices by which those pretended miracles were so long supported. To that work we refer our readers; requesting them, after they have read it, to compare the evidence for the miracles of Paris with the evidence which in the article MIRACLE, *Encycl.* we have stated for the reality of the Gospel miracles, and to judge for themselves with the impartiality of philosophers.

Paris wrote a few very indifferent books of annotations on the Epistles to the Romans, to the Galatians, and the Hebrews; but few have ever read them, nor would they have rescued the author from oblivion, without the aid of his lying wonders.

PARKHURST (the Rev. John), was the second son of John Parkhurst, Esq; of Catesby in Northamptonshire. His mother was Ricarda Dormer, daughter of Judge Dormer. He was born in June 1728, was educated at the school of Rugby in Warwickshire, and was afterwards of Clare-hall, Cambridge; B. A. 1748, M. A. 1752; and many years fellow of his college.

Being a younger brother, he was intended for the church; but not long after his entering into holy orders his elder brother died. This event made him the heir of a very considerable estate; though, as his father was still living, it was some time before he came into the full possession of it; and when he did come into the possession of it, the acquisition of fortune produced no change on his manners or his pursuits. He continued to cultivate the studies becoming a clergyman; and from his family connections, as well as from his learning and piety, he certainly had a good right to look forward to preferment in his profession; but betaking himself to retirement, and to a life of close and intense study, he sought for no preferment; and, according to the author of the biographical sketch of him published in the Gentleman's Magazine, he lived not in an age when merit was urged forward. Yet, in the capacity of a curate, but without any salary, he long did the duty, with exemplary diligence and zeal, in his own chapel at Catesby, which, after the demolition of the church of the nunnery there, served as a parish-church, of which also he was the patron.

When, several years after, it fell to his lot to exercise the right of presentation, he was so unfashionable as to consider church-patronage as a trust rather than a property; and, accordingly, resisting the influence of interest, favour, and affection, presented to the vicarage of Epsom, in Surrey, the Rev. Jonathan Boucher, who still holds it. This gentleman was then known to him only by character; but having distinguished himself in America, during the revolution, for his loyalty, and by teaching the unsophisticated doctrines of the church of England to a set of rebellious schismatics at the peril of his life, Mr Parkhurst thought, and justly thought, that he could not present to the vacant living a man who had given better proofs of his having a due sense of the duties of his office.

Parkhurst

In the year 1754, Mr Parkhurst married Susanna Myster, daughter, and, we believe, heiress of John Myster, Esq; of Epsom. It was thus that he became patron of the living which he bestowed on Mr Boucher. This lady died in 1759, leaving him a daughter and two sons; both the sons are now dead. In the year 1761, he married again Millicent Northey, daughter of Thomas Northey, Esq; by whom he had one daughter, now married to the Rev. Joseph Thomas.

In the year 1753, he began his career of authorship, by publishing, in 8vo, "A friendly address to the Rev. Mr John Wesley, in relation to a principal Doctrine maintained by him and his Assistants." This work we have not seen; but though we have no doubt of its value, we may safely say that it was of very little importance, when compared with his next publication, which was "An Hebrew and English Lexicon, without Points; to which is added, a methodical Hebrew Grammar, without Points, adapted to the use of Learners, 1762," 4to. To attempt a vindication of all the etymological and philosophical disquisitions which are scattered through this dictionary, would be very fruitless; but it is not perhaps too much to say, that we have nothing of the kind equal to it in the English language. He continued, however, to correct and improve it; and in 1778 another edition of it came out much enlarged, and a third in 1792.

His philological studies were not confined to the Hebrew language; for he published a Greek and English Lexicon to the New Testament; to which is prefixed, a plain and easy Greek Grammar, 1769, 4to; a second edition, 1794: and at his death there was in the press a new edition of both these lexicons; in a large 8vo, with his last corrections; for he continued to revise, correct, add to, and improve, these works, till within a few weeks of his death. As, from their nature, there cannot be supposed to be any thing in dictionaries that is particularly attractive and alluring, this continued increasing demand for these two seems to be a sufficient proof of their merit.

He published, "The Divinity and Pre-existence of our Lord and Saviour Jesus Christ, demonstrated from Scripture; in Answer to the first Section of Dr Priestley's Introduction to the History of early Opinions concerning Jesus Christ; together with Strictures on some other Parts of the Work, and a Postscript relating to a late Publication of Mr Gilbert Wakefield, 1787," 8vo. This work was very generally regarded as completely performing all that its title-page promised; and accordingly the whole edition was soon sold off. The brief, evasive, and very unsatisfactory notice taken

 taken of this able pamphlet by Dr Prieftley, in "A Letter to Dr Horne," &c. fhewed only that he was unable to anfwer it.

Mr Parkhurft was a man of very extraordinary independency of mind and firmnefs of principle. In early life, along with many other men of diftinguifhed learning, it was alfo objected to him, that he was an Hutchinfonian; and on this account alone, in common with them, it has been faid that he was neglected and fhunned.

There is not, in the hiftory of the times, fays the biographer already quoted, a circumftance more difficult to be accounted for than the unmerited, but increafing, difcountenance fhewn to thofe perfons to whom Hutchinfonianifm was then objected. Methodifts, Papifts, and fectaries of any and of every name, all ftood a better chance of being noticed and efteemed than Hutchinfonians. Had it even been proved that the few peculiar tenets by which they were diftinguifhed from other Chriftians were erroneous, the oppofition they experienced might have been deemed *hard meafure*, becaufe even their opponents allowed their principles to be inoffenfive, and themfelves to be learned.

Is this a fair ftate of the cafe? We think not. The early Hutchinfonians had imbibed all the peculiar notions of their mafter, and maintained them with a degree of acrimony which would have difgraced any caufe. Being in general very little acquainted with the higher mathematics, as Mr Hutchinfon himfelf feems likewife to have been, they cenfured dogmatically works which, without that knowledge, they could not fully underftand; whilft they maintained, with equal dogmatifm, as matters of fact, hypothefes, which a moderate fhare of mathematical fcience would have fhewn them to be impoffible. Had they ftopt here, no harm would have been done; they might have enjoyed their favourite notions in peace: but unfortunately they accufed of Atheifm, Deifm, or Socinianifm, all who thought not exactly as *they* thought, both in natural philofophy and in theology. Becaufe Newton and Clarke had demonftrated that the motions of the planets cannot be the effect of the impulfion of any material fluid, Hutchinfon, with fome of his followers, affirmed, that thefe two illuftrious men had entered into a ferious defign to overturn the Chriftian religion, and eftablifh in England the worfhip of the Heathen Jupiter, or the Stoical *anima mundi*. Becaufe the bifhops Pearfon, Bull, and others, who had uniformly been confidered as the ableft defenders of the Catholic faith, thought not exactly as Hutchinfon thought of the filiation of the Son of God, they were condemned by the pupils of his fchool as *Arians*, or at leaft *Semi-arians*; and the writer of this fketch has heard a living Hutchinfonian pronounce the fame cenfure, and for the fame reafon, on the prefent illuftrious Bifhop of Rochefter, and the no lefs illuftrious Whitaker.

That men, who thus condemned all that before them had been deemed great and good in phyfical fcience and Chriftian theology, fhould meet with fome difcountenance while they continued of fuch a fpirit, needs not furely excite much wonder; but that the difcountenance is increafing, we believe not to be true. The Hutchinfonians, as foon as they became lefs violent againft thofe who differed from them, had their fhare of preferment, in proportion to their number, with others; and we doubt not they will continue to have it, while they allow that a man may be no heretic, though he believe not Mr Hutchinfon to have been infallible. The late excellent Bifhop Horne was an avowed Hutchinfonian, though not an outrageous one like Julius Bate; and we have been told, and have reafon to believe, that the Bifhop of St Afaph is likewife a moderate favourer of the fame fyftem. There may be others on the epifcopal bench; but perhaps two out of twenty-fix is the full proportions of Hutchinfonian divines of eminence in England. It is true that Mr Parkhurft was a man of great learning and great worth; but before we attribute his want of preferment in the church to his Hutchinfonianifm, it is incumbent upon us to fay why Mr Whitaker, who is no Hutchinfonian, is ftill nothing more than the rector of Ruan-Lanyhorne.

Mr Parkhurft, however, was not, if his biographer deferves credit, a thorough-paced Hutchinfonian; for though he continued to read Hutchinfon's writings as long as he read at all, he was ever ready to allow, that he was oftentimes a confufed and bad writer, and fometimes unbecomingly violent. To have been deterred from reading the works of an author, who, with all his faults, certainly throws out many ufeful hints, for fear of being thought a Hutchinfonian, would have betrayed a pufillanimity of which Mr Parkhurft was incapable. What he believed he was not afraid to profefs; and never profeffed to believe any thing which he did not very fincerely believe. An earneft lover of truth, he fought it where only it is to be found—in the Scriptures (A). The ftudy of thefe was at once the bufinefs and the pleafure of his life; from his earlieft to his lateft years he was an hard ftudent: and had the daily occupations of every 24 hours of his life been portioned out, as it is faid thofe of king Alfred were, into three equal parts, there is reafon to believe that a deficiency would rarely have been found in the eight hours allotted to ftudy. What the fruits have been of a life fo conducted, few theologians, it is prefumed, need to be informed, it being hardly within the fcope of a fuppofition, that any man will now fit down to the ftudy of the Scriptures without availing himfelf of the affiftance to be obtained from his learned labours. Thefe labours ceafed at Epfom in Surrey, where this great and good man died, on March the 21ft, 1797. Befides the works which we have mentioned, there is in the Gentleman's Magazine, for Auguft 1797, a curious letter of his on the confufion of Tongues at Babel.

Mr Parkhurft's character may be collected with tolerable accuracy even from this imperfect fketch of his life. His notions of church patronage do him honour; and as a farther inftance of the high fenfe he entertain-

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(A) This is vague language, which is the fource of much ufelefs controverfy, and therefore ought to be avoided. If by *truth*, in this paffage, be meant *religious* truth, we admit the affertion in the only fenfe in which we think it can have been made. If the author means *all* truth, he writes nonfenfe; for the Scriptures treat not of *geometry* or *algebra*, where truth is certainly to be found; and *we think* that they have a higher object than even *mechanics* and *aftronomy*.

Parkhurst, Parkinson. ed of strict justice, and the steady resolution with which he practised it on all occasions, an incident which occurred between him and one of his tenants, within these ten years, may here be mentioned. This man falling behind hand in the payment of his rent, which was L. 500 *per annum*, it was represented to his landlord that it was owing to his being over-rented. This being believed to be the case, a new valuation was made; and it was then agreed that, for the future, the rent should not be more than L 450. Justly inferring, moreover, that if the farm was *then* too dear, it must necessarily have been *always* too dear, unasked, and of his own accord, he immediately struck off L. 50 from the commencement of the lease; and instantly refunded all that he had received more than L. 450 *per annum*.

Mr Parkhurst was in his person rather below the middle size, but remarkably upright, and firm in his gait. He was all his life of a sickly habit: and his leading so remarkably studious and sedentary a life (it having, for many years, been his constant practice to rise at five, and, in winter, to light his own fire) to the very verge of David's limits of the life of man, is a consolatory proof to men of similar habits, how much, under many disadvantages, may still be effected by strict temperance and a careful regimen. He also gave less of his time to the ordinary interruptions of life than is common. In an hospitable, friendly, and pleasant neighbourhood, he visited little; alleging, that such a course of life neither suited his temper, his health, nor his studies. Yet he was of sociable manners; and his conversation always instructive, often delightful: for his stores of knowledge were so large, that he too has often been called a walking library. He belonged to no clubs; he frequented no public places; and there are few men who, towards the close of life, may not, on a retrospect, reflect with shame and sorrow, how much of their precious time has thus been thrown away, or perhaps worse than thrown away.

Like many other men of infirm and sickly frames, Mr Parkhurst was also irritable, and quick, warm, and earnest, in his resentments, though never unforgiving. But whether it be or be not a matter of reproach to possess a mind so constituted, it certainly is much to any man's credit to counteract and subdue it by an attention to the injunctions of religion. This Mr Parkhurst effectually did: and few men have passed through a long life more at peace with his neighbours, more respected by men of learning, more beloved by his friends, or more honoured by his family.

Biog. Dict. PARKINSON (John). Of this ingenious English botanist, one of the first and most industrious cultivators of that science among us, the memorials that remain are very scanty. He was born in 1567, was bred an apothecary, and resided in London. He rose to such reputation in his profession as to be appointed apothecary to King James I.; and, on the publication of his Theatre of Plants, he obtained from the unfortunate successor of that prince the title of *Botanicus Regis primarius*. The time of his death cannot be exactly ascertained; but, as his Herbal was published in 1640, and it appears that he was living at that time, he must have attained his 73d year.

Parkinson's first publication was, his 1. *Paradisi in Sole Paradisus terrestris*, or, A Garden of all Sorts of Pleasant Flowers which our English Ayre will permit to be nursed up: with a Kitchen-garden of all manner of Herbes, Roots, and Fruits, for Meat or Sause, &c. &c. Collected by John Parkinson apothecary, of London, 1629, folio, 612 pages. In this work the plants are arranged without any exact order: nearly 1000 plants are separately described, of which 780 are figured on 129 tables, which appear to have been cut expressly for this work. Parkinson was, it is conceived, the first English author who separately described and figured the subjects of the flower-garden; and this book is therefore a valuable curiosity, as exhibiting a complete view of the extent of the English garden at the beginning of the 17th century. It may, perhaps, be necessary to inform the reader, that *Paradisus in Sole*, is meant to express the author's name, *Park in sun*.. 2. In 1640 he published his *Theatrum Botanicum;* or Theatre of Plants, or an Herbal of a large extent: containing therein, a more ample and exact History and declaration of the Physical Herbs and Plants than are in other Authors, &c. &c. London, folio, 1746 pages—This work had been the labour of the author's life; and he tells us that, owing to "the disastrous times," and other impediments, the printing of it was long retarded. Dr Pulteney is of opinion that, allowing for the defects common to the age, Parkinson will appear "more of an original author than Gerard or Johnson, independent of the advantages he might derive from being posterior to them. His theatre was carried on through a long series of years, and he profited by the works of some late authors, which Johnson, though they were equally in his power, had neglected to use. Parkinson's descriptions, in many instances, appear to be new. He is more particular in pointing out the places of growth. Johnson had described about 2850 plants, Parkinson has near 3800. These accumulations rendered the *Theatrum Botanicum* the most copious book on the subject in the English language; and it may be presumed that it gained equally the approbation of medical people, and of all those who were curious and inquisitive in this kind of knowledge."

Parkinson, Parsons. Biog. Dict. PARSONS (James), an excellent physician and polite scholar, was born at Barnstaple, in Devonshire, in March 1705. His father, who was the youngest of nine sons of Colonel Parsons, and nearly related to the baronet of that name, being appointed barrack-master at Bolton in Ireland, removed with his family into that kingdom soon after the birth of his then only son James, who received at Dublin the early part of his education, and, by the assistance of proper masters, laid a considerable foundation of classical and other useful learning, which enabled him to become tutor to Lord Kingston. Turning his attention to the study of medicine, he went afterwards to Paris, where (to use his own words) "he followed the most eminent professors in the several schools, as Astruc, Dubois, Lemery, and others; attended the anatomical lectures of the most famous [Hunaud and De Cat]; and chemicals at the King's Garden at St Come. He followed the physicians in both hospitals of the Hotel Dieu and La Charité, and the chemical lectures and demonstrations of Lemery and Bouldoc; and in botany Jussieu. Having finished these studies, his professors gave him honourable attestations of his having followed them with diligence

gence and induftry, which intitled him to take the degrees of doctor and profeffor of the art of medicine, in any univerfity in the dominions of France. Intending to return to England, he judged it unneceffary to take degrees in Paris, unlefs he had refolved to refide there; and as it was more expenfive, he therefore went to the univerfity of Rheims, in Champaign, where, by virtue of his atteftations, he was immediately admitted to three examinations, as if he had finifhed his ftudies in that academy; and there was honoured with his degrees June 11. 1736, In the July following he came to London, and was foon employed by Dr James Douglas to affift him in his anatomical works, where in fome time he began to practife. He was elected a member of the Royal Society in 1740; and, after due examination, was admitted a licentiate of the college of phyficians April 1. 1751; paying college fees and bond ftamps of different denominations to the amount of L. 41 : 2 : 8, fubject alfo to quarterage of L. 2 *per annum*. In 1755 he paid a farther fum of 7, which, with the quarterage money already paid, made up the fum of L. 16, in lieu of all future payments." On his arrival in London, by the recommendation of his Paris friends, he was introduced to the acquaintance of Dr Mead, Sir Hans Slone, and Dr James Douglas. This great anatomift made ufe of his affiftance, not only in his anatomical preparations, but alfo in his reprefentations of morbid and other appearances; a lift of feveral of which was in the hands of his friend Dr Maty, who had prepared an *eloge* on Dr Parfons, which was never ufed, but which, by the favour of Mrs Parfons, Mr Nichols has preferved at large. Though Dr Parfons cultivated the feveral branches of the profeffion of phyfic, he was principally employed in the obftetrical line. In 1738, by the intereft of his friend Dr Douglas, he was appointed phyfician to the public infirmary in St Giles's. In 1739 he married Mifs Elizabeth Reynolds, by whom he had two fons and a daughter, who all died young. Dr Parfons refided for many years in Red Lion Square, where he frequently enjoyed the company and converfation of Dr Stukely, Bifhop Littleton, Mr Henry Baker, Dr Knight, and many other of the moft diftinguifhed members of the Royal and Antiquarian Societies, and that of Arts, Manufactures, and Commerce; giving weekly an elegant dinner to a large but felect party. He enjoyed alfo the literary correfpondence of D'Argenville, Buffon, Le Cat, Beccaria, Amb. Betrand, Valltravers, Afcanios, Turberville Needham, Dr Garden, and others of the moft diftinguifhed rank in fcience. As a practitioner, he was judicious, careful, honeft, and remarkably humane to the poor; as a friend, obliging and communicative; chearful and decent in converfation, fevere and ftrict in his morals, and attentive to fill with propriety all the various duties of life. In 1769, finding his health impaired, he propofed to retire from bufinefs and from London; and with that view difpofed of a confiderable number of his books and foffils, and went to Briftol. But he returned foon after to his old houfe, and died in it after a week's illnefs, on the 4th of April, 1770. By his laft will, dated in October 1766, he gave his whole property to Mrs Parfons; and in cafe of her death before him, to Mifs Mary Reynolds her only fifter, "in recompence for her affectionate attention to him and to his wife, for a long courfe of years, in fickenefs and in health." It was his particular requeft, that he fhould not be buried till fome change fhould appear in his corpfe; a requeft which occafioned him to be kept unburied 17 days, and even then fcarce the flighteft alteration was perceivable. He was buried at Hendon, in a vault which he had caufed to be built on the ground purchafed on the death of his fon James, where his tomb had a very commendatory infcription.

It would carry us beyond our ufual limits to enter into an enumeration of the many curious articles at various times communicated to the public by Dr Parfons, which may be feen in the Anecdotes of Bowyer. We fhall therefore clofe this article with an extract from Dr Maty's eulogium: "The furprifing variety of branches which Dr Parfons embraced, and the feveral living as well as dead languages he had a knowledge of, qualified him abundantly for the place of affiftant fecretary for foreign correfpondences, which the council of the Royal Society beftowed upon him about the year 1750. He acquitted himfelf to the utmoft of his power of the functions of this place, till a few years before his death, when he refigned in favour of his friend, who now gratefully pays this laft tribute to his memory. Dr Parfons joined to his academical honours thofe which the Royal College of Phyficians of London beftowed upon him, by admitting him, after due examination, licentiate, on the firft day of April 1751. The diffufive fpirit of our friend was only equalled by his defire of information. To both thefe principles he owed the intimacies which he formed with fome of the greateft men of his time. The names of Folkes, Hales, Mead, Stukely, Needham, Baker, Colinfon, and Garden, may be mentioned on this occafion, and many more might be added. Weekly meetings were formed, where the earlieft intelligence was received and communicated of any difcovery both here and abroad; and new trials were made to bring to the teft of experience the reality or ufefulnefs of thefe difcoveries. Here it was that the microfcopical animals found in feveral infufions were firft produced; the propagation of feveral infects by fection afcertained; the conftancy of Nature amidft thefe wonderful changes eftablifhed. His Remains of Japhet, being Hiftorical Enquiries into the Affinity and Origin of the European Languages, are a moft laborious performance, tending to prove the antiquity of the firft inhabitants of thefe iflands as being originally defcended from Gomer and Magog, above 1000 years before Chrift, their primitive and ftill fubfifting language, and its affinity with fome others. It cannot be denied but that there is much ingenuity, as well as true learning, in this work, which helps conviction, and often fupplies the want of it. But we cannot help thinking that our friend's warm feelings now and then miflead his judgment, and that fome at leaft of his conjectures, refting upon partial traditions, and poetical fcraps of Irifh filids and Welfh bards, are lefs fatisfactory than his tables of affinity between the feveral northern languages, as deduced from one common ftock. Literature, however, is much obliged to him for having in this, as well as in many of his other works, opened a new field of obfervations and difcoveries. In enumerating our learned friend's differtations, we find ourfelves at a lofs whether we fhould follow the order of fubjects or of time; neither is it eafy to account

Parfons

account for their furprifing variety and quick fucceffion. The truth is, that his eagernefs after knowledge was fuch, as to embrace almoft with equal facility all its branches, and with equal zeal to afcertain the merit of inventions, and afcribe to their refpective, and fometimes unknown, authors, the glory of the difcovery. Many operations, which the ancients have tranfmitted to us, have been thought fabulous, merely from our ignorance of the art by which they were performed. Thus the burning of the fhips of the Romans at a confiderable diftance, during the fiege of Syracufe, by Archimedes, would perhaps ftill continue to be exploded, had not the celebrated M. Buffon in France fhewn the poffibility of it, by prefenting and defcribing a model of a fpeculum, or rather affemblage of mirrors, by which he could fet fire at the diftance of feveral hundred feet. In the contriving, indeed, though not in the executing of fuch an apparatus, he had in fome meafure been foreftalled by a writer now very little known or read. This Dr Parfons proved in a very fatisfactory manner; and he had the pleafure to find the French philofpher did not refufe to the Jefuit his fhare in the invention, and was not at all offended by the liberty he had taken. Another French difcovery, I mean a new kind of painting fathered upon the ancients, was reduced to its real value, in a paper which fhewed our author was poffeffed of a good tafte for the fine arts: and I am informed that his fkill in mufic was by no means inferior, and that his favourite amufement was the flute. Richly, it appears from thefe performances, did our author merit the honour of being a member of the Antiquarian Society, which long ago had affociated him to its labours. To another fociety, founded upon the great principles of humanity, patriotifm, and natural emulation, he undoubtedly was greatly ufeful (A). He affifted at moft of their general meetings and committees, and was for many years chairman to that of agriculture; always equally ready to point out and to promote ufeful improvements, and to oppofe the interefted views of fraud and ignorance, fo infeparable from very extenfive affociations. No fooner was *this* fociety (B) formed, than Dr Parfons became a member of it. Intimately convinced of the noblenefs of its views, though from his ftation in life little concerned in its fuccefs, he grudged neither attendance nor expence. Neither ambitious of taking the lead, nor fond of oppofition, he joined in any meafure he thought right; and fubmitted cheerfully to the fentiments of the majority, though againft his own private opinion. The juft ideas he had of the dignity of our profeffion, as well as of the common links which ought to unite all its members, notwithftanding the differences of country, religion, or places of education, made him bear impatiently the fhackles laid upon a great number of refpectable practitioners: he wifhed, fondly wifhed, to fee thefe broken; not with a view of empty honour and dangerous power, but as the only means of ferving mankind more effectually, checking the progrefs of defigning men and illiterate practitioners, and diffufing through the whole body a fpirit of emulation. Though by frequent difappointments he forefaw, as well as we, the little chance of a fpeedy redrefs, he nobly perfifted in the attempt; and had he lived to the final event, would undoubtedly, like Cato, ftill have preferred the conquered caufe to that fupported by the gods. After having tried to retire from bufinefs and from London, for the fake of his health, and having difpofed of moft of his books with that view, he found it inconfiftent with his happinefs to forfake all the advantages which a long refidence in the capital, and the many connections he had formed, had rendered habitual to him. He therefore returned to his old houfe, and died in it, after a fhort illnefs, April 4. 1770. The ftyle of our friend's compofition was fufficiently clear in defcription, tho' in argument not fo clofe as could have been wifhed. Full of his ideas, he did not always fo difpofe and connect them together, as to produce in the minds of his readers that conviction which was in his own. He too much defpifed thofe additional graces which command attention when joined to learning, obfervation, and found reafoning. Let us hope that his example and fpirit will animate all his colleagues: and that thofe practitioners who are in the fame circumftances will be induced to join their brethren, fure to find amongft them thofe great bleffings of life, freedom, equality, information, and friendfhip. As long as thefe great principles fhall fubfift in this fociety, and I truft they will outlaft the longeft liver, there is no doubt but the members will meet with the reward honeft men are ambitious of, the approbation of their confcience, the efteem of the virtuous, the remembrance of pofterity."

Parfons || Paffigraphy.

PARODICAL Degrees, in an equation, a term that has been fometimes ufed to denote the feveral regular terms in a quadratic, cubic, bequadratic, &c. equation, when the indices of the powers afcend or defcend orderly in an arithmetical progreffion. Thus, $x^3 + m x^2 + n x = p$ is a cubic equation where no term is wanting, but having all its parodic degrees; the indices of the terms regularly defcending thus, 3, 2, 1, 0.

PARTY Arches, in architecture, are arches built between feparate tenures, where the property is intermixed, and apartments over each other do not belong to the fame eftate.

Party Walls, are partitions of brick made between buildings in feparate occupations, for preventing the fpread of fire. Thefe are made thicker than the external walls; and their thicknefs in London is regulated by act of Parliament of the 14th of George III.

PASSIGRAPHY, the art of writing on any fubject fo as to be underftood by all nations (See *Univerfal Characters* in this *Supplement*). In France, where every thing is admired that is new, and every vagary of the imagination of a pretended philofopher thought practicable, a propofal has lately been made to introduce one univerfal language into the world, conftructed by a few metaphyficians on the laws of human thought. And to this language, in its written form, is to be given the name of *paffigraphy*. Such readers as think this idle

nd dream

(A) The Society for the Encouragement of Arts, Manufactures, and Commerce. He likewife was affociated to the Economical Society at Berne, Dec. 26. 1763.

(B) A Medical Society inftituted by Dr Fothergill, and other refpectable phyficians, licentiates, in vindication of their privileges; where, it fhould feem, this eulogy was intended to be pronounced.

dream worthy their attention (which is far from being the cafe with us), will find fome ingenious thoughts on the hiftory of a philofophical language, in the 2d volume of *Nicholfon's Journal of Natural Philofophy, &c.*

PATH OF THE VERTEX, a term frequently ufed by Mr Flamfteed in his Doctrine of the Sphere, denoting a circle, defcribed by any point of the earth's furface as the earth turns round its axis. This point is confidered as vertical to the earth's centre; and is the fame with what is called the vertex or zenith in the Ptolomaic projection.

PEARL FISH, is commonly confidered as an *afcidia* (fee MYTILUS, *Encycl.*); but this is denied by a late author, who feems to have paid great attention to the pearl-fifhery at Ceylon. It has never, he fays, been accurately defcribed. It does not refemble the *afcidia* of Linnæus; and as he thinks it may form a new genus, he gives the following account of it:

"The fifh is faftened to the upper and lower fhells by two white flat pieces of mufcular fubftance, which have been called ears, and extend about two inches from the thick part of the body, growing gradually thinner. The extremity of each ear lies loofe, and is furrounded by a double brown fringed line. Thefe lie almoft the third part of an inch from the outer part of the fhell, and are continually moved by the animal. Next to thefe, above and below, are fituated two other double fringed moveable fubftances, like the bronchiæ of a fifh. Thefe ears and fringes are joined to a cylindrical piece of flefh of the fize of a man's thumb, which is harder and of a more mufcular nature than the reft of the body. It lies about the centre of the fhells, and is firmly attached to the middle of each. This, in fact, is that part of the pearl-fifh which ferves to open and fhut the fhells. Where this column is faftened, we find on the flefh deep impreffions, and on the fhell various nodes of round or oblong forms, like imperfect pearls. Between this part and the hinge (*cardo*) lies the principal body of the animal, feparated from the reft, and fhaped like a bag. The mouth is near the hinge of the fhell, enveloped in a veil, and has a double flap or lip on each fide; from thence we obferve the throat (*œfophagus*) defcending like a thread to the ftomach. Clofe to the mouth there is a curved brownifh tongue, half an inch in length, with an obtufe point; on the concave fide of this defcends a furrow, which the animal opens and fhuts, and probably ufes to convey food to its mouth. Near its middle are two bluifh fpots, which feem to be the eyes. In a pretty deep hole, near the bafe of the tongue, lies the beard (*byffus*), faftened by two flefhy roots, and confifting of almoft 100 fibres, each an inch long, of a dark green colour, with a metallic luftre; they are undivided, parallel, and flattened. In general, the *byffus* is more than three quarters of an inch without the cleft (*rima*); but if the animal is difturbed, it contracts it confiderably. The top of each of thefe threads terminates in a circular gland or head, like the *ftigma* of many plants. With this *byffus* they faften themfelves to rocks, corals, and other folid bodies; by it the young pearl-fifh cling to the old ones, and with it the animal procures its food, by extending and contracting it at pleafure. Small fhell fifh, on which they partly live, are often found clinging to the former. The ftomach lies clofe to the root of the beard, and has, on its lower fide, a protracted obtufe point. Above the ftomach are two fmall red bodies, like lungs; and from the ftomach goes a long channel or gut, which takes a circuit round the mufcular column above-mentioned, and ends in the anus, which lies oppofite to the mouth, and is covered with a fmall thin leaf, like a flap. Though the natives pretend to diftinguifh the fexes by the appearance of the fhell, calling the flat ones males, and thofe which are thick, concave, and vaulted, females, our author, on a clofe infpection, could not perceive any vifible fexual difference."

The pearls are only in the fofter part of the animal, and never in the firm mufcular column above-mentioned. They are found, in general, near the earth, and on both fides of the mouth. From the appearance of the fhell a judgment may be formed, with greater or lefs probability, whether it contains pearls or not. Thofe which have a thick calcareous cruft upon them, to which *ferpulæ* (fea tubes) *Tubuli mariæ irregulariter intorti, Crifta-gali Chamar lazuras, Lepas tintinabulum, Madreporee, Millipore, Cellipore, Gorgontæ, Spongiæ*, and other Zoophytes, are faftened, have arrived at their full growth, and commonly contain the beft pearls; but thofe that appear fmooth, contain either none, or fmall ones only.

In the article (*Encycl.*) intitled, *Manner of Fifhing for PEARLS in the Eaft Indies*, we have moft unaccountably faid, that "the beft divers will keep under water near *half an hour*, and the reft not lefs than a quarter!" This is a very great miftake; for M. *Le Beck* affures us, that the time during which a diver is able to remain under water feldom exceeds two minutes; and that, even after that fhort period, he difcharges, on emerging from the fea, a quantity of water, and fometimes a little blood, from his mouth and nofe. We have mentioned the danger which the divers run of becoming a prey to monftrous fifhes. Thefe fifhes are fharks; of which fuch a dread is juftly entertained, that the moft expert divers will not, on any account, defcend, till the conjurer has performed his ceremonies of enchantment. Thefe confift in a number of prayers, learned by heart, that nobody, probably not even the conjurer himfelf, underftands, which he, ftanding on the fhore, continues muttering and grumbling from fun-rife until the boats return. During this period, he is obliged to abftain from food and fleep, otherwife his prayers would have no avail: he is, however, allowed to drink; which privilege he indulges in a high degree, and is frequently fo giddy, as to be rendered very unfit for devotion. Some of the conjurers accompany the divers in their boats; which pleafes them very much, as they have their protectors near at hand.

PEDOMETER (fee *Encycl.*), is the name given by Mr Lewin Thugwell to an inftrument, which is rather an improved PERAMBULATOR than the inftrument which we have noticed by the name of Pedometer. The chief improvement made by him on the PERAMBULATOR (fee that article, *Encycl.*) is in the fize of the wheel, of which the circumference meafures $16\frac{1}{2}$ feet, or one pole, adapted to Gunter's concife method of arithmetic, and divided into 25 equal parts, correfponding to the links of his chain for land-meafuring. There is likewife a contrivance in Mr Thugwell's pedometer, for compelling the attention of the traveller to the inftrument at the end of every mile. It is very ingenious, and abundantly fimple; but we hardly think it of fuffi-

cient

cient importance to fill the ſpace which a complete deſcription of it would occupy in this work. It is fully deſcribed in the *Letters and Papers of the Bath and Weſt of England Society, for the Encouragement of Agriculture;* and likewiſe in the 6th volume of the *Repertory of Arts and Manufactures*.

PEGUE, the ancient capital of the kingdom of the ſame name (ſee PEGU, *Encycl.*), appears to have been a quadrangle, each ſide meaſuring about a mile and a half. It was ſurrounded by a ditch and wall; which, before the latter tumbled down, and the former was filled up, muſt have furniſhed no contemptible defence. The breadth of the ditch appears to be about 60 yards; its depth, where not choked up, about ten or twelve feet; and there is ſtill in it water enough to impede an eaſtern ſiege. The wall has been at leaſt 25 feet high, and its breadth at the baſe not leſs than 40. It is compoſed of brick, badly cemented together with clay mortar, and has had on it ſmall equidiſtant baſtions, about 300 yards aſunder.

Nothing can exhibit a more ſtriking picture of deſolation than the inſide of this wall. We have elſewhere given an account of the almoſt inceſſant wars between the kings of Pegue and Birma or Barma. In the year 1757, the Birman ſovereign carried the city of Pegue by aſſault, razed every dwelling to the ground, and diſperſed, or led into captivity, all the inhabitants. The pagodas, which are very numerous, were the only buildings that eſcaped the fury of the conqueror; and of theſe the great pagoda of SHOEMADOO has alone been attended to, and repaired.

This extraordinary edifice is built on a double terrace, one raiſed upon another. The lower and greater terrace is about ten feet above the natural level of the ground. It is quadrangular. The upper and leſſer terrace is of a like ſhape, raiſed about 20 feet above the lower terrace, or 30 above the level of the country. Theſe terraces are aſcended by flights of ſtone ſteps, broken and neglected. On each ſide are dwellings of the *Rahaans* or prieſts, raiſed on timbers four or five feet from the ground. Their houſes conſiſt only of a ſingle hall. The wooden pillars that ſupport them are turned with neatneſs. The roof is of tile, and the ſides of ſheathing-boards. There are a number of bare benches in every houſe, on which the *Rahaans* ſleep. They appear to have no furniture.

Shoemadoo is a pyramid, compoſed of brick and plaſter, with fine ſhell mortar, without excavation or aperture of any ſort: octagonal at the baſe, and ſpiral at the top. Six feet from the ground there is a wide ledge, which ſurrounds the baſe of the building; on the plane of which are 57 ſmall ſpires, of equal ſize, and equidiſtant. One of them meaſured 27 feet in height, and 40 in circumference at the bottom. On a higher ledge there is another row, conſiſting of 53 ſpires, of ſimilar ſhape and meaſurement. A great variety of mouldings encircles the building; and ornaments, ſomewhat reſembling the *fleur de lys*, ſurround what may be called the baſe of the ſpire. Circular mouldings likewiſe gird this part to a conſiderable height; above which there are ornaments in ſtucco, not unlike the leaves of a Corinthian capital; and the whole is crowned by a *tee*, or umbrella of open iron-work, from which riſes an iron rod with a gilded pendant.

The extreme height of the building, from the level of the country, is 361 feet; and above the interior terrace, 331 feet. On the ſouth eaſt angle of the upper terrace there are two handſome ſaloons, or *keouns*, lately erected. The roof is compoſed of different ſtages, ſupported by pillars. Captain Symes, from whoſe memoir in the Aſiatic Reſearches this account is taken, judged the length of each ſaloon to be about 60 feet, and the breadth 30. The ceiling of one of them was already embelliſhed with gold leaf, and the pillars lacquered; the other, when he ſaw it, was not completed. They are made entirely of wood. The carving on the outſide is very curious. He ſaw ſeveral unfiniſhed figures, intended to be fixed on different parts of the building; ſome of them not ill ſhapen, and many exceedingly groteſque. Splendid images of Gaudma (the *Birman* object of adoration) were preparing, which he underſtood were deſigned to occupy the inſide of theſe *keouns*.

At each angle of the interior terrace is a pyramidical pagoda, 67 feet in height, reſembling, in miniature, the great pagoda. In front of the one in the ſouth-weſt corner are four gigantic repreſentations in maſonry of Palloo, or the *man deſtroyer*, half beaſt, half human, ſeated on their hams, each with a large club on the right ſhoulder.

Nearly in the centre of the eaſt face of the area are two human figures in ſtucco beneath a gilded umbrella. One ſtanding, repreſents a man with a book before him, and a pen in his hand. He is called *Thagiamee*, the recorder of mortal merits and mortal miſdeeds. The other, a female figure kneeling, is *Maha Sumdere*, the protectreſs of the univerſe, as long as the univerſe is doomed to laſt: but when the time of general diſſolution arrives, by her hand the world is to be overwhelmed, and deſtroyed everlaſtingly.

On the north ſide of the great pagoda are three large bells, of good workmanſhip, ſuſpended near the ground between pillars. Several deers horns are ſtrewed around. Thoſe who come to pay their devotions firſt take up one of the horns, and ſtrike the bell three times, giving an alternate ſtroke to the ground. This act is to announce to the ſpirit of Gaudma the approach of a ſuppliant. There are ſeveral low benches near the bottom of the pagoda, on which the perſon who comes to pray places his offering; which generally conſiſts of boiled rice, a plate of ſweetmeats, or cocoa-nut fried in oil. When it is given, the devotee cares not what becomes of it. The crows and dogs commonly eat it up in the preſence of the donor, who never attempts to prevent or moleſt the animals.

There are many ſmall pagodas on the areas of both terraces, which are neglected, and ſuffered to fall into decay. Numberleſs images of Gaudma lie indiſcriminately ſcattered. A pious Birman who purchaſes an idol, firſt procures the ceremony of conſecration to be performed by the *Rahaans*, then takes his purchaſe to whatever ſacred building is moſt convenient, and there places it either in the ſhelter of a *keoun*, or on the open ground before the temple: nor does he ever after ſeem to have any anxiety about its preſervation, but leaves the divinity to ſhift for itſelf.

From the upper ledge that ſurrounds the baſe of Shoemadoo, the proſpect of the country is extenſive and pictureſque; but it is a proſpect of Nature in her rudeſt ſtate. There are few inhabitants, and ſcarcely

any

Pegue. any cultivation. The hills of *Martaban* rife to the eaft-ward: and the *Sitang* river, winding along the plains, gives here and there an interrupted view of its waters. To the north-north weft, above 40 miles, are the *Galladzet* hills, whence the Pegue river takes its rife; hills remarkable only for the noifome effects of their atmofphere. In every other direction the eye looks over a boundlefs plain, chequered by a wild intermixture of wood and water.

The prefent king of the Birmans has entirely altered the fyftem of his predeceffors. He has turned his attention to the population and improvement, rather than the extenfion, of his dominions; and feems more defirous to conciliate his new fubjects by mildnefs, than to rule them through terror. He has abrogated feveral fevere penal laws impofed upon the *Taliens* or Peguers: juftice is now diftributed impartially; and the only diftinction at prefent between a Birman and Talien confifts in the exclufion of the latter from all public offices of truft and power.

No act of the Birman government is more likely to reconcile the Taliens to the Birman yoke than the reftoration of their ancient place of abode, and the prefervation and embellifhment of the pagoda of Shoemadoo. So fenfible was the king of this, as well as of the advantages that muft accrue to the ftate from an increafe of culture and population, that fome years ago he iffued orders to rebuild Pegue, encouraged new fettlers by liberal grants, and invited the fcattered families of former inhabitants to return and repeople their deferted city.

Pegue, in its renovated ftate, feems to be built on the plan of the former city. It is a fquare, each fide meafuring about half a mile. It is fenced round by a ftockade, from 10 to 12 feet high. There is one main ftreet running eaft and weft, which is interfected at right angles by two fmaller ftreets, not yet finifhed. At each extremity of the principal ftreet there is a gate in the ftockade, which is fhut early in the evening. After that hour, entrance during the night is confined to a wicket. Each of thefe gates is defended by a forry piece of ordnance, and a few mufqueteers, who never poft centinels, and are ufually afleep. There are alfo two other gates on the north and fouth fides of the ftockade.

The houfes of the inhabitants of Pegue are far from commodious, agreeably to European notions of accommodation; but they are at leaft as much fo as the houfes of other Indian towns. There are no brick buildings in Pegue, except fuch as belong to the king, or are dedicated to Guadma. The king has prohibited the ufe of brick or ftone in private buildings, from the apprehenfion, that if people got leave to build brick houfes, they might erect brick fortifications, dangerous to the fecurity of the ftate. The houfes, therefore, are all made of mats or fheathing-boards, fupported on bamboos or pofts. Being compofed of fuch combuftible materials, the inhabitants are under continual dread of fire, againft which they take every precaution. The roofs are lightly covered; and at each door ftands a long bamboo, with a hook at the end, to pull down the thatch: alfo another pole, with a grating of fplit bamboo at the extremity, about three feet fquare, to fupprefs flame by preffure. Almoft every houfe has earthen pots of water on the roof. And there is a particular clafs of people, whofe bufinefs it is to prevent and extinguifh fires.

Peifhcar || Pell.

PEISHCAR, in Bengal, principal in office.

PEISHCUSH, a fine, tribute, or prefent.

PELL (Dr John), an eminent Englifh mathematician, defcended from an ancient family in Lincolnfhire, was born at Southwick in Suffex, March 1. 1610, where his father was minifter. He received his grammar education at the free fchool at Stenning in that county. At the age of 13 he was fent to Trinity college in Cambridge, being then as good a fcholar as moft mafters of arts in that univerfity; but though he was eminently fkilled in the Greek and Hebrew languages, he never offered himfelf a candidate at the election of fcholars or fellows of his college. His perfon was handfome; and being of a ftrong conftitution, ufing little or no recreations, he profecuted his ftudies with the more application and intenfenefs.

In 1629 he drew up the "Defcription and Ufe of the Quadrant, written for the Ufe of a Friend," in two books; the original manufcript of which is ftill extant among his papers in the Royal Society. And the fame year he held a correfpondence with Mr Briggs on the fubject of logarithms.

In 1630, he wrote *Modus fupputandi Ephemerides Aftronomicas, &c. ad. an.* 1630 *accommodatus*; and, A Key to unlock the meaning of Johannes Trithemius, in his Difcourfe on Steganography: which Key he imparted to Mr Samuel Hartlib and Mr Jacob Homedæ. The fame year he took the degree of Mafter of Arts at Cambridge. And the year following he was incorporated in the Univerfity of Oxford. June the 7th, he wrote A Letter to Mr Edmond Wingate on Logarithms: and, Oct. 5. 1631, *Commentationes in Cofmographiam Alftedii.*

In 1632 he married Ithamaria, fecond daughter of Mr Henry Reginolles of London, by whom he had four fons and four daughters.—March 6. 1634, he finifhed his "Aftronomical Hiftory of Obfervations of Heavenly Motions and Appearances;" and April the 10th, his *Ecliptica Prognoftica*, or Foreknower of the Eclipfes, &c. In 1634 he tranflated "The Everlafting Tables of Heavenly Motions," grounded upon the Obfervations of all Times, and agreeing with them all, by Philip Lanfberg, of Ghent in Flanders. And June the 12th, the fame year, he committed to writing "The Manner of Deducing his Aftronomical Tables out of the Tables and Axioms of Philip Lanfberg."—March the 9th, 1625, he wrote, "A Letter of Remarks on Gellibrand's Mathematical Difcourfe on the Variation of the Magnetic Needle." And the 3d of June following, another on the fame fubject.

His eminence in mathematical knowledge was now fo great, that he was thought worthy of a Profeffor's chair in that fcience; and, upon the vacancy of one at Amfterdam in 1639, Sir William Bofwell, the Englifh Refident with the States General, ufed his intereft, that he might fucceed in that Profefforfhip. It was not filled up, however, till 1642, when Pell was chofen to it; and he read with great applaufe public lectures upon Diophantus. In 1644 he printed at Amfterdam, in two pages 4to, "A Refutation of Longomontanus's Difcourfe," *De Vera Circuli Menfura.*

Pell.

In 1646, on the invitation of the Prince of Orange, he removed to the new college at Breda, as Profeſſor of Mathematics, with a ſalary of 1000 guilders a year. His *Idea Matheſeos*, which he had addreſſed to Mr Hartlib, who in 1639 had ſent it to Des Cartes and Merſenne, was printed 1650 at London, in 12mo, in Engliſh, with the title of *An Idea of Mathematics*, at the end of Mr John Durie's Reformed Library-keeper. It is alſo printed by Mr Hook, in his Philoſophical Collections, N° 5. p. 127. ; and is eſteemed our author's principal work.

In 1652 Pell returned to England; and in 1654 he was ſent by the Protector Cromwell agent to the Proteſtant Cantons in Switzerland; where he continued till June 23. 1658, when he ſet out for England, where he arrived about the time of Cromwell's death. His negociations abroad gave afterwards a general ſatisfaction, as it appeared he had done no ſmall ſervice to the intereſt of King Charles II. and of the church of England; ſo that he was encouraged to enter into holy orders: and in the year 1661 he was inſtituted to the rectory of Fobbing in Eſſex, given him by the king. In December that year, he brought into the upper houſe of convocation the kalendar reformed by him, aſſiſted by Sancroft, afterwards archbiſhop of Canterbury. In 1673 he was preſented by Sheldon, biſhop of London, to the rectory of Laingdon in Eſſex; and upon the promotion of that biſhop to the ſee of Canterbury ſoon after, became one of his domeſtic chaplains. He was then doctor of divinity, and expected to be made a dean; but his improvement in the philoſophical and mathematical ſciences was ſo much the bent of his genius, that he did not much purſue his private advantage. The truth is, he was a helpleſs man, as to wordly affairs; and his tenants and relations impoſed upon him, cozened him of the profits of his parſonage, and kept him ſo indigent, that he wanted neceſſaries, even ink and paper, to his dying day. He was for ſome time confined to the King's bench priſon for debt; but in March 1682, was invited by Dr Whitler to live in the college of phyſicians. Here he continued till June following; when he was obliged, by his ill ſtate of health, to remove to the houſe of a grand-child of his in St Margaret's church-yard, Weſtminſter. But he died at the houſe of Mr Cothorne, reader of the church of St Giles's in the Fields, December the 12th, 1685, in the 74th year of his age, and was interred at the expence of Dr Buſhby, maſter of Weſtminſter ſchool, and Mr Sharp, rector of St Giles's, in the rector's vault under that church.—Dr Pell publiſhed ſome other things not yet mentioned; a liſt of which is as follows, *viz.*

1. An Exercitation concerning Eaſter; 1644, in 4to, 2. A Table of 10,000 ſquare numbers, &c.; 1672, folio 3. An Inaugural Oration at his entering upon the Profeſſorſhip at Breda. 4. He made great alterations and additions to Rhonius's Algebra, printed at London 1668, 4to, under the title of An Introduction to Algebra, tranſlated out of the High Dutch into Engliſh by Thomas Branker, much altered and augmented by D. P. (Dr Pell). Alſo a Table of Odd Numbers, leſs than 100,000, ſhewing thoſe that are incompoſite, &c. ſupputated by the ſame Thomas Branker. 5. His Controverſy with Longomontanus concerning the Quadrature of the Circle; Amſterdam, 1646, 4to.

Pell, Pelletier.

He likewiſe wrote a Demonſtration of the 2d and 10th books of Euclid; which piece was in MS. in the library of Lord Brereton in Cheſhire: as alſo Archimedes's Arenarius, and the greateſt part of Diophantus's ſix books of Arithmetic; of which author he was preparing, Auguſt 1644, a new edition, in which he intended to correct the tranſlation, and make new illuſtrations. He deſigned likewiſe to publiſh an edition of Apollonius; but laid it aſide, in May 1645, at the deſire of Golius, who was engaged in an edition of that author from an Arabic manuſcript, given him at Aleppo 18 years before. Letters of Dr Pell to Sir Charles Cavendiſh, in the Royal Society.

Some of his manuſcripts he left at Brereton in Cheſhire, where he reſided ſome years, being the ſeat of William Lord Brereton, who had been his pupil at Breda. A great many others came into the hands of Dr Buſby; which Mr Hook was deſired to uſe his endeavours to obtain for the Society. But they continued buried under duſt, and mixed with the papers and pamphlets of Dr Buſby, in four large boxes, till 1755; when Dr Birch, ſecretary to the Royal Society, procured them for that body, from the truſtees of Dr Buſby. The collection contains, not only Pell's mathematical papers, letters to him, and copies of thoſe from him, &c. but alſo ſeveral manuſcripts of Walter Warner, the mathematician and philoſopher, who lived in the reigns of James I. and Charles I.

Dr Pell invented the method of ranging the ſeveral ſteps of an algebraical calculus, in a proper order, in ſo many diſtinct lines, with the number affixed to each ſtep, and a ſhort deſcription of the operation or proceſs in the line. He alſo invented the character ÷ for diviſion, ⊕ for involution, ɯ for evolution*.

* Hutton's Mathematical Dictionary.

PELLETIER (Bertrand), was born at Bayonne in 1761, and very ſoon began to diſplay an inſatiable thirſt of ſcience. It frequently happens, however, that young men, ſincerely deſirous of inſtruction, have no means or place where they can be aſſiſted in the developement of their natural talents, no maſter who may point out the direct road to ſcience, and that order and method, without which the efforts of the individual too often lead him from the object of his purſuit, inſtead of bringing him nearer to it. This was not the caſe with young Pelletier. He found every advantage in his father's houſe, where he received the firſt elements of the art of which he was afterwards the ornament; and his ſubſequent progreſs was made under Darcet, who having remarked in him that ſagacity which may be called the inſtinct of ſcience, admitted him among the pupils attached to the chemical laboratory of the college of France. Five years of conſtant application and ſtudy under ſuch a maſter, who was himſelf formed by nature, perfected by experience, and affectionately diſpoſed towards his pupil, afforded this young man a ſtock of knowledge very unuſual at his age. He ſoon gave a convincing proof of this, by publiſhing, at the age of 21, a ſet of very excellent obſervations on the arſenical acid. Macquer, by mixing nitre with the oxide of arſenic, had diſcovered in the reſidue of this operation a ſalt ſoluble in water, ſuſceptible of cryſtallization in tetrahedral priſms, which he denominated the neutral arſenical arfenical falt. It is the arfeniat of potafh. He was of opinion that no acid could decompofe it; but Pelletier fhewed, that the fulphuric acid diftilled from it does difengage the acid of arfenic. He fhewed the true caufe why the neutral arfenical falt is not decompofable in clofed veffels; and particularly the order of affinity by which the falt itfelf is formed in the diftillation of the nitrate of potafh, and the white oxide of arfenic. He explains in what refpects this falt differs from what Macquer called the liver of arfenic. Pelletier had been anticipated in this work by Scheele, by Bergman, by the academicians of Dijon, and by Berthollet; but he poffeffed at leaft the merit, in the firft effay of his powers, of having clearly developed all the phenomena of this operation, by retaining and even determining the quantity of gas it was capable of affording. After the fame principles it was that he decompofed the arfenico-ammoniacal falt, by fhewing how, in the decompofition of this laft, the pure arfenical acid is obtained in the form of a deliquefcent glafs. In this work we may obferve the fagacity with which he was enabled to developе all the phenomena of thefe compofitions and decompofitions, by tracing thofe delicate threads of fcientific relation which connect the feries of facts, and are imperceptible to ordinary minds.

Encouraged by the fuccefs of thefe firft works, which he prefented with the fenfibility of grateful attachment to his inftructor, he communicated his obfervations on the cryftallization of fulphur, cinnabar, and the deliquefcent falts; the examination of zeolites, particularly the falfe zeolite of Frihourg in Brifgaw, which he found to be merely an ore of zinc; obfervations on the dephlogifticated or oxygenated muriatic acid, relative to the abforption of oxygen; on the formation of ethers, particularly the muriatic and the acetous; and feveral memoirs on the operation of phofphorus made in the large way; its converfion into phofphoric acid, and its combination with fulphur and moft metallic fubftances.

It was by his operations on that moft aftonifhing production of chemiftry, phofphorus, that he burned himfelf fo dangeroufly as nearly to have loft his life. After the cure of his wound, which confined him to his bed for fix months, he immediately began the analyfis of the various plumbagos of France, England, Germany, Spain, and America, and found means to give novelty and intereft to his work, even after the publication of Scheele on the fame fubject. The analyfis of the carbonet of barytes led him to make experiments on animals; which prove that this earth is a true poifon, whether it be adminiftered in the form of the native carbonat of barytes, or whether it be taken from the decompofition of the fulphat, even though again combined with another acid.

Chemifts have given the name of *ftrontian* to a newly difcovered earth, from the name of the place where it was firft found. Pelletier analyfed it, and difcovered it in the fulphat of barytes. He likewife analyfed the verditer of England, of which painters and paper-hangers make fo much ufe. He difcovered a procefs for preparing it in the large way, by treating with lime the precipitate obtained from the decompofition of nitrat of copper by lime. By his procefs, verditer is afforded equal in beauty to that which comes from England. He was likewife one of the firft chemifts who fhewed the poffibility of refining bell metal, and feparating the tin. His firft experiments were made at Paris; after which he repaired to the foundary at Romilly, to verify them in the large way. The following year he was received a member of the Academy of Sciences at Paris, and fhortly afterwards went to La Fere, with Borda and General Daboville, to affift in experiments upon a new gunpowder. Being obliged, in order to render his experiments more decifive, to pafs great part of the day in the open air during a cold and humid feafon, his health, which was naturally delicate, became confiderably impaired. He began to recover his health, when he again became the victim of his zeal for the fcience he fo fuccefsfully cultivated. He had nearly perifhed by refpiring the oxygenated muriatic acid gas. A violent attack of convulfive afthma, which returned during feveral days, was the firft confequence of this unhappy accident. The diforder then feemed to abate; but it was incurable. The affiftance of art was infufficient to fave him; and he died in Paris, on the 21ft of July 1797, of a pulmonary confumption, in the flower of his age.

PENDULUM (See *Encycl.*). Befides the effects of heat and cold on the length of the pendulum rod, and of courfe on its ifochronifm, it may certainly be worth while, in the conftruction of clocks intended to meafure time with the utmoft poffible exactnefs, to take into confideration the refiftance of the air, which, by its unequal denfity, varying the weight of the pendulum, muft in a fmall degree accelerate or retard its motion. The celebrated David Rittenhoufe, who paid particular attention to this fubject, eftimates the extreme difference of velocity, arifing from this caufe, at half a fecond a day; and he obferves, that a remedy dependent on the barometer will not be ftricty accurate, as the weight of the entire column of air does not precifely correfpond with the denfity of its bafe. He propofes, therefore, as a very fimple and eafy remedy, that the pendulum fhall, as ufual, confift of an inflexible rod carrying the ball beneath, and continued above the centre of fufpenfion to an equal (or an unequal) diftance upwards. At this extremity is to be fixed another ball of the fame dimenfions (or greater or lefs, according as the continuation is fhorter or longer), but made as light as poffible. The ofcillations of this upper ball will be accelerated by its buoyancy by the fame quantity as thofe of the lower would be retarded; and thus, by a proper adjuftment, the two effects might be made to balance and correct each other.

Our author made a compound pendulum on thefe principles, of about one foot in its whole length. This pendulum, on many trials, made in the air 57 vibrations in a minute. On immerfing the whole in water, it made 59 vibrations in the fame time; fhewing evidently, that its returns were quicker in fo denfe a medium as water than in the air. (This is contrary to what takes place with the common pendulum). When the lower bob or pendulum only was plunged in water, it made no more than 44 vibrations in a minute.

PENNANT (Thomas, Efq.), fo well known in the republic of letters as a writer of travels and of natural hiftory, was an ancient Briton by birth, having drawn his firft breath in Flintfhire, in 1726. His family has been fettled in that county for many centuries; we learn from himfelf that he received the rudiments of his education at Wrexham, whence he was removed to Fulham. Soon after this he was fent to Oxford; and ha-

Pennant. ving made a considerable proficiency in the classics, he applied himself within the walls of that university to attain a knowledge of jurisprudence; but we do not find that he ever entered himself of any of the inns of court, or followed the law as a profession.

The ruling passions of mankind are excited, and the future current of their lives frequently directed, by trivial circumstances. One of the greatest painters of our age was attracted with an irresistible impulse towards his art by the perusal of a treatise on it; and we have the authority of the subject of this memoir for asserting, that a present of Willughby's Ornithology, at an early period, first gave him a turn for natural history, which has never once abandoned him through the course of a very long life.

Mr Pennant commenced his travels with great propriety at home, where he made himself acquainted with the manners, productions, and curiosities, of his native country, before he sallied forth to inspect those of other nations. He then repaired to the continent; and not only acquired considerable additional knowledge relative to his favourite studies, but became acquainted, and established a correspondence, with some of the greatest men of the age.

On his return he married, and had two children, but did not come into the family fortune until he was thirty-seven years of age, at which time he was settled at Downing.

Having lost his wife, he appears to have set out once more for the continent, and to have formed an acquaintance with Voltaire, Buffon, Haller, Pallas, &c. He had by this time acquired considerable reputation as a scientific man, having commenced his career as an author so early as 1750. His British Zoology* established his reputation as a naturalist; and this received a fresh accession of celebrity in consequence of his acquaintance with Linnæus, and his intercourse by letters with all the celebrated naturalists in Europe.

* Four vols 4to.

Early in life he had undertaken a most interesting tour to Cornwall; and he now entertained an ardent desire to survey the works of nature in the northern extremities of the island. He accordingly set out for Scotland, and in 1771 favoured the public with an entertaining account of his Tour †, which was so well received as to pass through several editions. Not content with the main land of Great Britain, he was ambitious to survey the islands in the vicinity, and accordingly penetrated to the Hebrides, and visited Man.

† Three vols 4to.

It is not to be supposed that he would leave his own country unexplored; on the contrary, he minutely described all its wonders. He did not fail on this occasion to present the world with the result of his enquiries, for in 1778 he commenced the publication of his Welsh Tour§.

§ Two vol. 4to.

In four years after this (1782) appeared the account of the Journey from Chester to London‡, in which he refutes the vulgar opinion that it is uninteresting; and in two years more his Arctic Zoology, an admirable work, greatly prized both here and in other countries.

‡ One vol. 4to.

In 1790 appeared a quarto volume, simply entitled Of London; in which he observes that this work is composed from observations, originally made without any view of publication. "Let me request (says he in the preface) the good inhabitants of London and Westminster not to be offended at my having stuffed their Iliad into a nutshell; the account of the city of London and liberties of Westminster into a quarto volume. I have condensed into it all I could; omitted nothing that suggested itself; nor amplified any thing to make it a guinea book. In a word, it is done in my own manner, from which I am growing too old to depart.

"I feel within myself a certain monitor that warns me (adds he) to hang up my pen in time, before its powers are weakened, and rendered visibly impaired. I wait not for the admonition of friends. I have the Archbishop of Grenada in my eye; and fear the imbecility of human nature might produce in long worn age the same treatment of my kind advisers as poor Gil Blas had from his most reverend patron. My literary bequests to future times, and more serious concerns, must occupy the remnant of my days. This closes my public labours."

Notwithstanding his parting address, the example of the Archbishop of Grenada, and the concluding sentence of "*Valete & Plaudite*," we find Mr Pennant adventuring once more in the ocean of literature, at a late period of his life, and trying his fortune again with all the eagerness of a young author.

He accordingly published the Natural History of the parishes of Holywell and Downing*, within the precincts of the latter of which he had resided about half a century.

* One vol. 4to.

He also presented the public, a very short time before his death, with a splendid work, consisting of 2 vols. 4to. entitled The View of Hindoostan; in the preface to which he candidly states his motives for this new attempt. "I had many solicitations from private friends (says he), and a few wishes from persons unknown, delivered in the public prints, to commit to the press a part, in the form in which the posthumous volumes might hereafter make their appearance. I might have pleaded the imprudence of the attempt at my time of life, of beginning so arduous an undertaking in my 71st year.

"I happily, till very lately, had scarcely any admonition of the advanced season. I plunged into the sea of trouble, and with my papers in one hand, made my way through the waves with the other, and brought them secure to land. This, alas! is finite boasting. I must submit to the judgment of the public, and learn from thence how far I am to be censured for so grievous an offence against the maxim of Aristotle, who fixes the decline of human abilities to the 49th year.

"I ought to shudder, when I consider the wear and tear of 22 years; and feel shocked at the remark of the elegant Delanty, who observes, 'that it is generally agreed among wise men, that few attempts, at least in a learned way, have ever been wisely undertaken and happily executed after that period!'

"I cannot defend the wisdom: yet from the good fortune of my life I will attempt the execution."

These valuable volumes are drawn up by Mr Pennant in the manner of his introduction to the Arctic Zoology. The plates, 23 in number, are admirably engraved, and one (the Napaul pheasant) is beautifully coloured.

In addition to the list of literary labours already enumerated, is a letter on an earthquake felt at Downing, in Flintshire, in 1753; another inserted in the same publi-

Pennant, Pennatula. publication*, in 1756, on coralloid bodies (κοραλλοειδης) collected by him: his Synopsis of Quadrupeds, published in 1771; a pamphlet on the Militia; a paper on the Turkey: and a volume of Miscellanies.

Phil. Trans.

Mr Pennant attained academical honours of all kinds, having had the degree of LL. D. conferred on him by the university in which he was educated, he was a Fellow of the Royal Society, and a member of the Society of Antiquaries, a Fellow of the Royal Society of Upsal in Sweden, a member of the American Philosophical Society, an honorary member of the Anglo Linnæan Society, &c.

The ample fortune left him by his father enabled Mr Pennant to keep an hospitable table, and also to present the profits of several of his works to public institutions, particularly the Welsh charity-school in Gray's-inn-lane. He encouraged several engravers by his patronage, and was not a little serviceable to the advancement of the fine arts.

In 1776 he married a second time; on which occasion he became united to Miss Mostyn, sister of his neighbour, the late Sir Roger Mostyn, in Flintshire. The latter part of his life was chearful, and he scarcely felt the approaches of old age. He died at his seat at Downing in his 72d year.

He has left several works behind him in MS. under the title of Outlines of the Globe; and as a proof that it will be a very voluminous and interesting publication, it is only necessary to observe, that the View of Hindoostan composed the xivth and xvth volumes.

Mr Pennant possessed a well-compacted frame of body, an open and intelligent aspect, an active and chearful disposition, and a vivacity which rendered him always entertaining, as well in conversation as in writing. Though not without a share of irrascibility, his heart was kind and benevolent. He was examplary in the relations of domestic life, and sensibly felt for the distresses of his poor neighbours, whose relief in seasons of hardship he promoted with great zeal and liberality, His candour and freedom from ordinary prejudices, are sufficiently displayed in his writings; and Scotland was forward to confess, that he was the first traveller from this side the Tweed, who had visited the country with no unfriendly spirit, and had fairly presented it under its favourable as well as its less pleasing aspects. As a writer, his style is lively and expressive, but not perfectly correct. His principles of arrangement in zoology are judicious, and his descriptions characterestic. If in some of his later works a little vanity appears, and a propensity to think that important to the world which was so to himself, it may readily be pardoned to one who has afforded such copious and valuable entertainment to the public. His name will live with honour in the literary history of his country, and his memory will be cherished with respect and affection by his surviving friends.

PENNATULA (See *Encycl.*) A species of this animal, hitherto undescribed, was discovered by La Martiniere near Nootka. Its body is of a cartilaginous substance, and a cylindrical form; its head, armed with two little horns of the same substance, presents a spherical figure flatted at its interior extremity. This part is covered with small papillæ, some of which are visible at D, and which serve the purpose of small mouths, by means of which this animal sucks the blood of fishes, making its way as far as possible into the flesh: the extremity of its body, which always projects from the fish, appears like the feathers of a pen; these feather-like substances serve as excretory vessels: for on making a slight pressure on the animal, from the greater part of these cartilaginous barbs issued small drops of a very limpid liquor: at the base of these barbs, and beneath the body, are placed two large cartilaginous threads, of which our author could not imagine the use, for they are not universally met with in each individual. The circulation of its blood is readily observed, it forms a complete revolution about once in a minute. It is probable that this animal is only able to make its way into the bodies of different fish when it is very young; and when it has once buried itself there, having abundance of nourishment, its head increases considerably, and the two horns with which it is furnished necessarily form an obstacle to its regress, which is a remarkable instance of the foresight of Nature, since it is destined to be nourished at the expence of another. The pennatula, of which we have given from Martiniere a figure, was found by him at the depth of more than an inch and an half in the body of a *diodon*.

Plate XLI.

Pepusch.

PEPUSCH (John Christopher), one of the greatest theoretic musicians of modern times, as we are told, was born at Berlin about 1667; and became so early a proficient on the harpsichord, that at the age of 14 he was sent for to court, and appointed to teach the prince, father of the late King of Prussia. About 1700, he came over to England, and was retained as a performer at Drury Lane: it is supposed that he assisted in composing the operas which were performed there. While he was thus employed, he forbore not to prosecute his private studies; and these led him to enquire into the music of the ancients, and the perusal of the Greek authors upon that subject. The abilities of Pepusch, as a practical composer, were not likely to become a source of wealth to him: his music was correct, but it wanted variety of modulation. Besides, Handel had got possession of the public ear, in the opinion of whose superior merit he readily acquiesced; and chose a tract for himself, in which he was almost sure to meet with no obstruction. He became a teacher of music, not the practice of any particular instrument, but music in the absolute sense of the word, that is to say, the principles of harmony and the science of practical composition; and this, not to children or novices, but in very many instances to professors of music themselves.

In 1713, he was admitted to the degree of Doctor in Music at Oxford, and continued to prosecute his studies with great assiduity. In 1724, he accepted an offer from Dr Berkeley to accompany him to the Burmudas, and to settle as professor of music in his intended college there; but the ship in which they sailed being wrecked, he returned to London, and married Francesca Margarita de l'Epine. This person was a native of Tuscany, and a celebrated singer, who performed in some of the first of the Italian operas that were represented in England. She came hither with one Greber, a German, and from this connection became distinguished by the invidious appellation of *Greber's Peg*. Afterwards she commenced a new connection with Daniel Earl of Nottingham, who had defended the orthodox notion of the Trinity against the heretic Whiston; and to this connection Rowe, in imitation of Horace's

Horace's, "Ne fit ancillæ tibi amor pudori," thus alludes:

> Did not bafe Greber's Peg inflame
> The fober Earl of Nottingham,
> Of fober fire defcended?
> That, carelefs of his foul and fame,
> To play-houfes he nightly came,
> And left church undefended.

She continued to fing on the ftage till about 1718; when having, at a modeft computation, acquired above ten thoufand guineas, fhe retired from the theatre, and afterwards married Dr Pepufch. She was remarkably tall, and remarkably fwarthy; and, in general, fo deftitute of perfonal charms, that Pepufch feldom called her by any other name than Hecate, to which fhe is faid to have anfwered very readily.

The change in Pepufch's circumftances by Margarita's fortune was no interruption to his ftudies: he loved mufic, and he purfued the knowledge of it with ardour. At the inftance of Gay and Rich, he undertook to compofe, or rather to correct, the mufic for the Beggar's Opera. His reputation was now at a great height. He had perufed with great attention thofe feveral ancient treatifes on Harmonics, publifhed by Meibomius, and that of Ptolemy by Dr Wallis; and the difficulties which occurred to him on the perufal, were in a great meafure removed by his friend De Moivre the mathematician, who affifted him in making calculations for demonftrating thofe principles on which the harmonic fcience is founded. In confequence of thefe ftudies, he was efteemed, in matters of theory, one of the beft muficians of his time. In 1737, he was chofen organift of the Charter-houfe, and retired, with his wife, to that venerable manfion. The wife died in 1740, before which he loft a fon, his only child; fo that he had no fource of delight left, but the profecution of his ftudies, and the teaching of a few favourite pupils, who attended him at his apartments. Here he drew up that account of the ancient genera which was read before the Royal Society, and is publifhed in the Philofophical Tranfactions for October, November, and December, 1746; and, foon after the publication of that account, he was chofen a Fellow of the Royal Society.

He died the 20th of July, 1752, aged 85; and was buried in the chapel of the Charter-houfe, where a tablet with an infcription is placed over him.*

* Biog. Dict. new edit.

PERCUSSION, Force of Percussion, is the name by which mechanicians diftinguifh that faculty of producing motion, or making other fenfible mechanical impreffions on bodies, by means of the ftroke of a body in motion. It is nearly the fame with *impulfe;* only, it would feem that the very fcrupulous and refined effect to limit the attention to the *immediate* caufe of the motion, or other effect produced; to the fomething that is different, both from the force fuppofed to be inherent in the moving body (a hammer for example), and the fubfequent motion and penetration of the nail which is driven by it. We may venture to fay that it is needlefs to attempt any inveftigation of this object. It is hid, with all other caufes of all other effects in the univerfe, in impenetrable darknefs. If we reflect on the conftitution of our own mind, fo far as we can know it by experience and obfervation, and on the manner in which we draw conclufions, we muft fee that the knowledge of the efficient caufe of any effect is unattainable; for were the intervening fomething pointed out to us, and clearly conceived by us, we fhould find it juft as neceffary to find out why and how this fomething is connected with each of the events which we obferve it invariably to connect.

But a knowledge of the force of percuffion, in as far as it may or may not be diftinguifhable from other forces, is not unattainable. We can learn as much, and no more, concerning this, as concerning any other force; and we can contemplate that circumftance which, in our opinion, is common to it with all other forces, and may perhaps difcover other circumftances in which it differs from them. But in all this difquifition, it is plain that it is only events, which we conceive to be the characteriftic effects of the caufe, that we contemplate.

Percuffion, confidered as an effect, characteriftic of a particular faculty of moving bodies, became an object of anxious refearch, almoft as foon as philofophers began to think of motion and moving forces at all. The ancients (as has been obferved in the article Impulsion, *Suppl.*) contented themfelves with very vague fpeculations on the fubject. Galileo was the firft who confidered it as a meafurable thing, the object of mathematical difcuffion; being encouraged by his precious difcovery of the laws of accelerated motion, and the very refined meafure which thefe gave him of the power of gravity. It was a meafure of the heavinefs, not of the weight, of the body; and this was meafured by its acceleration, and not by its preffure. Encouraged by this, he hoped to find fome fuch meafure of the force of percuffion, which he faw fo intimately connected with motion; whereas its connection with preffure was far from being obvious. He therefore tried to convert the terms; and as he had found a meafure of the preffure of gravity in the acceleration of motion, he endeavoured to find in preffure a meafure of the force of purcuffion arifing from this acceleration. He endeavoured to find the number of pounds, whofe preffure is equal to the blow of a given body, moving with a given velocity. The velocity was known to him with great precifion, by means of the height from which the ball muft fall in order to acquire it. It feems pretty clear that percuffion may be meafured in this way; for a body falling from a height will pierce an uniformly tenacious body to a certain degree, and no further; and experiment fhews that this degree of penetration is very precife and conftant. The fame body, being merely laid on the tenacious body, will penetrate to a fmall depth by its weight. Laying more weight on it, will make it penetrate deeper; and a certain weight will make it penetrate as deep as the fall did, and no deeper. Thus, percuffion feems very eafily meafurable by weight, or by any preffure fimilar to that of weight. It appears that Galileo made experiments with this view, and that he was difappointed, and obliged to acquiefce in the opinion of Ariftotle, that percuffion and weight are incomparable. He propofes, therefore, another experiment, namely, to drop a body into the fcale of a balance from greater and greater heights, till at laft the blow on the fcale raifes a weight that lies on the other fcale. This offers itfelf fo plaufibly, that we are perfuaded that Galileo tried it: but as he makes no mention

tion of the refults, we prefume that they were unfatisfactory.

Neither of thefe experiments *could* give us a meafure of the force of percuffion, if this force be any thing different from the forces which are excited or brought into action by percuffion, in the manner defcribed in the article Impulsion, *Suppl.* When the ball comes into phyfical contact with the fcale, it begins to comprefs it. This compreffion begins to ftretch the ftrings by which the fcale is fupported. Thefe pull at the arm of the balance, and caufe it to prefs the centre-pin a little harder on its fupport, and to bend the balance a little, and caufe it to pull at the cords which fupport the other fcale. That fcale is pulled upwards, diminifhing a little its preffure on the ground, and preffing it harder to the incumbent weight. Thefe forces are excited *in fucceffion* from the one fcale to the other, and a fmall moment of time elapfes. The re-action of the fcale diminifhes, but does not inftantaneoufly annihilate, the velocity of the falling ball. It therefore compreffes the fcale ftill more, ftretches the threads, preffes the fulcrum, and bends the balance ftill more (becaufe the weight in the other fcale keeps it down). The velocity of the falling ball is rapidly diminifhed ; the balance is more bent, and pulls more ftrongly upwards at the threads of the other fcale ; and thus preffes that fcale more ftrongly againft the incumbent weight, gradually communicating more and more motion to it, removing it farther from the ground, till, at laft, the motion becomes fenfible, or fo confiderable as to difengage fome delicate catch as a fignal. The experiment is now finifhed ; and the mechanician fondly thinks that, at this inftant, the preffure excited by the percuffion, between the oppofite fcale and the under fide of the incumbent weight, is juft equal, or but a very little fuperior, to the preffure of the incumbent weight : and, fince the arms of the balance are equal, and therefore the preffures on the two fcales are equal, he imagines that that weight exerts a preffure equal to the percuffion of the falling ball.

But all this is mifconception, and alfo falfe reafoning. It is not percuffion that we are meafuring, but the preffures excited by percuffion, on the two fcales. And thefe preffures are the forces of elafticity or expanfivenefs, belonging to, or inherent in, the particles of the balls and the fcales ; forces which are brought into action by the approach of thofe bodies to each other. This reafoning is alfo erroneous ; and we fhould be miftaken if we think that the preffure actually exerted is equal to that of the weight in the oppofite fcale. It is greater than the mere preffure of that weight. The re-action of the oppofite fcale on its load was precifely equal to that weight before the ball was dropped from the hand ; and, had the ball been equal to that weight, and fimply laid into the fcale on which it falls, it would have made no change on the mutual preffures of the fcale and the other weight ; it would only have relieved the ground from the preffure of that weight, and would have brought it on the threads which fupport its fcale. The preffure of this fcale upwards muft be increafed, before it can ftart the weight fenfibly from the ground. How much it muft be increafed depends on the fpringinefs of the fcales, cord, and beam. By a proper adjuftment of thefe particulars, the apparatus will give us almoft any meafure of percuffion that we choofe. For this reafon, the improvements made on it by Gravefande are of no value. The fame reafoning, nearly, may be applied to the meafurements of the force of percuffion by means of the penetration of foft bodies.

Galileo mentions another very curious experiment, by which he thought that he had obtained a juft meafure of percuffion. A veffel, filled with water, was fufpended on the arm of a balance, with another veffel hanging from it, a great way below. All was exactly balanced by a weight in the oppofite fcale. By means of a fuitable contrivance, a hole was opened in the bottom of the upper veffel, without difturbing the equilibrium. As foon as the water iffued, and while it was falling through the air, that end of the balance rofe ; but when the water ftruck the lower veffel, the equilibrium was reftored, and continued during the whole time of the efflux. Hence Galileo concluded, that the force of the ftroke was equal to the weight of the falling water. But we apprehend that the obfervations made on this in the article Impulsion, *Suppl.* will convince the reader that this conclufion is far from being legitimate. Befides, the ftroke, in any one inftant, is made by thofe particles only which ftrike in that inftant, while the whole vein of water between the veffels is neither acting by its weight on the upper veffel, nor by its ftroke on the lower ; and we fhould conclude from the experiment, that the force of percuffion is infinitely greater than the weight of the ftriking body. Indeed this is the inference made by Galileo. But if we have recourfe to the experiments and reafonings of Daniel Bernoulli, in the article *Resistance of Fluids*, *Encycl.* we fhall find that the feeming impulfe on the lower veffel is really a moft complicated pure preffure, and of moft uncertain determination. The experiment is valuable, and gives room for curious reflections. We have repeated it, in a great variety of forms, and with great changes of impulfe, and fometimes in fuch a manner that no impulfe whatever can obtain, while at the fame time a quantity of water was filling, unfupported by either veffel. In all the trials the equilibrium remained undifturbed. We were obliged to conclude, therefore, that the experiment afforded no meafure of percuffion. Indeed we were of this opinion before making the trial, for the reafons juft now given.

We cannot fay that the fubfequent labours of philofophers have added much to our knowledge of this matter. Mr Leibnitz had contrived his whimfical doctrine of *living* and *dead* forces. The action of gravity, or of a fpring, is a *vis viva*, when it actually produces motion in the body on which it acts ; but when a ftone lies on a table, and preffes on it, this preffure is a *vis mortua*. Its exertion is made, and in the fame inftant deftroyed, by an oppofite *vis mortua*. Each of thefe exertions would have produced *a beginning* of motion (fomething different from any of the fmalleft local motion) ; and the fum of all would, after a certain time, have amounted to a fenfible motion and velocity. There feems no diftinct conception to accompany, or that can accompany, this language. And, as a proof that Leibnitz had no diftinct conceptions of the matter, he has recourfe to this very experiment of Galileo in fupport of his genefis of a fenfible motion from the continual exertions of the *vis mortua* ; and he concludes that the force of percuffion is infinitely, or incomparably, greater than preffure, becaufe it is the fum total of an infinity of individual

dual exertions of *vis mortua*. Nothing but the authority which Leibnitz has acquired on the continent, by the zealous efforts of his partizans, could excuse our taking up any time in considering this unintelligible discourse. Surely, if there is such a thing as a *vis viva*, it exists in the moving water, and its impulsions are not continual exertions of a *vis mortua*. Nor is it possible to conceive continual impulse, nor a beginning of motion that is not motion, &c. &c. It is paradoxical (and Leibnitz loved to raise the wonder of his followers by paradoxes) to say that percussion is infinitely greater than pressure, when we see that pressure can do every thing that can be done by percussion. Nay, Euler, by far the most able supporter of the doctrines of Leibnitz about the force of bodies in motion, actually compares these two forces; and, in his Commentary on Robins's Artillery, demonstrates, in his way, that when a musket ball, moving with the velocity of 1700 feet per second, penetrates five inches into a block of elm, the force of its percussion is 107,760 times its weight. John Bernoulli restricts the infinite magnitude of percussion to the case of perfectly hard bodies; and, for this reason alone, says, that there can be none such in the universe. But, as this justly celebrated mathematician scouts with scorn the notion of attractions and repulsions, he must allow, that an ultimate atom of matter is unchangeable in its form; which we take to be synonymous with saying that it is perfectly hard. What must be the result of one atom in motion hitting another at rest? Here must be an instantaneous production of a finite velocity, and an infinite percussion. A doctrine which reduces its abettors to such subterfuges, and engages the mind in such puzzling contemplations, cannot (to say the best of it) be styled an EXPLANATION of the laws of Nature. The whole language on the subject is full of paradoxes and obscurities. In order to reconcile this infinite magnitude of percussion with the observed finite magnitude of its effects, they say that the pressure, or instantaneous effort, has the same relation to the force of percussion that an element has to its integral; and in maintaining this assertion, they continually consider this integral under the express denomination of a *sum total*, robbing Leibnitz's great discovery of the infinitesimal calculus of every superiority that it possessed over Wallis's Arithmetic of infinites, and really employing all the erroneous practices of the method of indivisibles. We look upon the strange things which have been inculcated, with pertinacious zeal, in this doctrine of percussion and *vires vivæ*, as the most remarkable example of the errors into which the unguarded use of Cavalerius's Indivisibles, and of the Leibnitzian notion of the infinitesimal calculus, have led eminent mathematicians. It is not true that the pressure, and the ultimate force of percussion, have this relation; nor has the pressure and the resulting motion, which is mistaken for the measure of this ultimate force, any mathematical relation whatever. The relation is purely physical; it is the relation of pure cause and effect: and all that we know of it is their constant conjunction. The relation of fluxion and fluent is not a mathematical or measurable relation, but a connection in thought; which is sufficient for making the one an indication of the other, and the measures of the proportions of the one a mean for obtaining a measure of the proportions of the other. In this point of view, the relation of pressure to motion, as the measure of the force of percussion, *resembles* that of fluxion and fluent, but is not the same.

Much has been said by the partizans of Mr Leibnitz about the incomparableness of pressure and percussion, and many experimental proofs have been adduced of the incomparable superiority of the latter. Bulfinger says, that the pressure of many tons will not cause a spike to penetrate a block of hard oak half so far as it may be driven by a weak man with one blow of a mallet; and that a moderate blow with a small hammer will shiver to powder a diamond, which would carry a mountain without being hurt by its pressure. Nay, even Mr Camus, of the Academy of Paris, a staunch Cartesian, and an eminent mechanician, says that he beat a leaden bullet quite flat with a hammer of one pound weight, without much force; and that he found that 200 pounds weight would not have flattened it more than this blow: and he concludes from thence, that the force of the blow exceeded 200 pounds. These, to be sure, are remarkable facts, and justify a more minute consideration of a power of producing certain effects, which is so frequently and so usefully employed. But, at the same time, these are all very vague expressions, and they do not authorise any precise conclusions from them. Mr Camus saying "without much force," makes his pound weight, and his 200 pound weight, of no use for determining the force of the blow. He would have given more precise and applicable data for his decision, had he told us from what height the hammer should fall in order to flatten the bullet to this degree. But even then we should not have obtained any notion of the force in actual exertion during the flattening of the bullet; for the blow which could flatten the bullet in a longer or a shorter time, would unquestionably have been less or greater.

All the paradoxes, obscurities, and puzzling difficulties, in this subject disappear, if we leave out of our consideration that unintelligible force, which is supposed to preserve a body in motion or at rest; and if we consider both of these states of body as conditions which will continue, unless some adequate cause operate a change; and if we farther grant, that such causes do really exist in the universe, however unknown their nature may be by us; and, lastly, if we acknowledge, that the phenomena of elasticity, expansiveness, cohesion, gravity, magnetism, electricity, are indications of the agency of such causes, and that their actual exertions, and the motions and changes consequent on these exertions, are so invariably connected with particular bodies, that they always accompany their appearance in certain mutual relations of distance and position:—if we proceed thus, all the phenomena of collision will be explained by these causes alone, without supposing the existence and agency of a cause distinct from them all, and incomparable with them, called the FORCE OF PERCUSSION.

For it has been sufficiently demonstrated in the article IMPULSION (*Suppl.*), that that property of tangible coherent matter, which we call *perfect elasticity*, operates as a pressure during a certain small portion of time on both bodies, diminishing more and more the motion of the one, and augmenting that of the other, as the compression of one or both increases, till at last they separate with sensible velocities. In some very simple or perspicuous

Percussion spicuous cases, we know what this pressure is in every instant of the action. We can tell how many pounds weight, at rest, will exert the same pressure. We can tell the whole duration of this pressure, and the space along which it is exerted; and, in such a case, we can say with precision what motion will be generated by this continued and varied pressure on the body which was at rest, and what diminution will be made in the motion of the other. All this can be done in the case Plate XLI. of a ball A (fig. 1.), moving like a pendulum with a small velocity, and striking a slender elastic hoop B, also suspended like a pendulum. We can ascertain by experiment, before the collision, what pressure is necessary for compressing it one inch, one-half, one-fourth, &c. Knowing this, and the weight of the hoop, and the weight and velocity of the ball, we can tell every circumstance of the collision—how long the compression continues—what is the greatest compression—how far the bodies have moved while they were acting on each other—and what will be the final motion of each:—in short, every thing that affords any mark or measure of a force of percussion. And we know that all this is produced by a force, familiarly known to us by the name of elasticity. Which of all these circumstances shall be called the precussion, or the force of percussion? Is it the ultimate or greatest pressure occasioned by the compression? This cannot be, because this *alone* will not be proportional to the final change of motion, which is generally taken as a measure of the percussion when a change of motion is its only observed effect.

We know that another perfectly elastic body, of the same weight, and struck by the same blow, and acquiring the same final velocity by the stroke, may not have sustained the tenth part of the pressure, in any one instant of the collision, if it has only been much more compressible. The greatest mutual pressure in the collision of a billiard ball is perhaps 1000 times greater than it is in a similar collision of a foot ball of the same weight.

We also know what degree of compression will break this hoop, and what pressure will produce this compression. Therefore, should the fracture of the body be considered as the mark and measure of the percussion, we know what blow will just produce it, and be exhausted by so doing. In short, we know every mark and measure of percussion which this hoop can exhibit.

We can increase the strength of this hoop till it becomes a solid disk; and we see clearly, that in all these forms the mode of acting is the same. We see clearly that it is the same when, instead of the solid disk, it is an elastic ball; therefore every thing that can indicate or measure the percussion of an elastic ball, is explained without the operation of a peculiar force of percussion, even when the ball is shivered to pieces by the blow.

Nor is the case materially different when the bodies are soft, or imperfectly elastic. When the struck body is uniformly tenacious, it opposes a uniform resistance to penetration, and its motion will be uniformly accelerated by the action of its own tenacity during the whole time of mutual action, except a trifling variation occasioned by the mere motion of the internal parts, independent of their tenacity. If we knew the weight necessary for merely penetrating this mass, and the weight and velocity of the penetrating body, we can tell how long it must be resisted by this force before Percussion. its initial velocity will be annihilated, and therefore how far it will penetrate. We have tried this with deal, birch, willow, and other soft woods of uniform texture, and with nails having the body somewhat slenderer than the end, that there might not be an irregularity occasioned by a friction on the sides of the nail, continually increasing as the penetration advanced. We made the hammer fall from a considerable height, and hit the nail with great accuracy in the direction of its length, by fixing it to the end of a long lath, moveable round an axis. The results corresponded with the calculation with all the precision that could be desired.

But it does not result from all this agreement, that the force, exertion, or effect, of a blow with a hammer is equal to the pressure of any number of pounds whatever. They are things that cannot be compared; and yet the force operating in the penetration by a blow is no way different from pressure. It is a physical blunder to compare the area of the curve, whose abscissa is the depth of penetration, and the ordinates are as the resistances, with any pressure whatever. This area expresses the square of a velocity, and its slips, bounded by parallel ordinates indefinitely near each other, are as the decrements of this square of a velocity, occasioned by a pressure, acting almost uniformly along a very small space, or during a very small time. It is an absurdity therefore to sum up these slips as so many pressures, and to consider the sum total as capable of expressing any weight whatever. Such a paralogism is peculiar to Leibnitz's way of conceiving his infinitesimal method, and it could have no place in the genuine method of fluxions. It is this misconception that has made Mr Leibnitz and his followers suppose that a body, accelerated by gravity, retains in it a sum total of all the pressures of gravity accumulated during its fall, and now forming a *vis viva*. Supposing that it requires a pressure of twenty pounds to press a six pound shot slowly through a mass of uniformly resisting clay; this pressure would carry it from the top to the bottom of a mountain of such clay. Yet this ball, if discharged horizontally from a cannon, would penetrate only a few yards, even though the clay should resist by tenacity only, independent of the motion lost by giving *motion* to its internal parts. In this experiment the utmost pressure exerted during the motion of the ball did not much exceed the pressure of twenty pounds. In this comparison, therefore, percussion, so far from appearing infinitely greater than pressure, would appear much less. But there is perhaps nobody that resists penetration with perfect uniformity, even though uniformly tenacious. When the ball has penetrated to some depth, the particles which are before it cannot be so easily displaced, even although they had no tenacity, because the particles adjoining are more hemmed in by those beyond them. We have always observed, that a ball impelled by gunpowder through water rises toward the surface (having entered horizontally through the side of the vessel at some depth), and this so much the more rapidly as it entered nearer to the surface. The reason is plain. The particles which must be displaced before the ball, escape more easily upwards than in any other direction. It is for this reason chiefly that a greater weight laid on the head of a nail will cause it sink deeper into the wood; and thus a great weight appears to to be commenſurable with a great force of percuſſion. Alſo while a bullet is flattening more and more under a hammer during the progreſs of a blow, it is ſpreading under the hammer; more particles are reſiſting at once, and they find more difficulty in effecting their eſcape, being harder ſqueezed between the hammer and the anvil. The ſame increaſed reſiſtance muſt obtain while it is flattening more and more under the quiet preſſure of a weight; and thus, too, a great weight appears to be commenſurable with a greater blow.

After all, however, a blow given by a falling body muſt excite a preſſure greater than its mere weight can do, and this in any degree. Thus, ſuppoſe AB (fig. 2.) to repreſent a ſpiral ſpring in its natural unconſtrained dimenſions, ſtanding upright on a table. Let $a\ b$ be the abſciſſa of a line $a\ d\ h\ k$, whoſe ordinates $c\ d$, $g\ h$, $i\ k$, &c. are as the elaſtic reaction of the ſpring when it is compreſſed into the lengths $c\ b$, $g\ b$, $i\ b$, &c. Suppoſe that, when it is compreſſed into the form CD, it will juſt ſupport the weight of a ball lying on C. Then $c\ d$ will be a reaction equal to the weight of the ball, and the rectangle $a\ c\ d\ f$ will expreſs the ſquare of the velocity which this ball would acquire by falling freely through $a\ c$. If therefore the ball be gently laid on the top of the ſpring at A, and then let go, it will deſcend, compreſſing the ſpring. It will not ſtop when the ſpring has acquired the form CD, which enabled it to carry the weight of the ball gently laid on it. For in this ſituation it has acquired a velocity of which the ſquare is repreſented by the figure $a\ d\ f$. (See Dynamics, *Suppl.* n° 95.). It will compreſs the ſpring into the length $g\ b$, ſuch that the area $c\ g\ h\ d$ is equal to the area $a\ d\ f$. If the ball, inſtead of being gently laid on A, be dropped from M, it will compreſs the ſpring into ſuch a length $i\ b$, that the area $a\ i\ k$ is equal to the rectangle $m\ c\ d\ n$; and, if the ſpring cannot bear ſo great compreſſion, it will be broken by this very moderate fall.

Thus we ſee that a blow may do things which a conſiderable preſſure cannot accompliſh. The accounts which are given of theſe remarkable effects of percuſſion, with the view of impreſſing notions of its great efficacy, are generally in very indefinite terms, and often without mentioning circumſtances which are acceſſory to the effect. It would be very unfair to conclude an almoſt infinite power of percuſſion, from obſerving, that a particle of ſand, dropped into a thick glaſs bottle which has not been annealed, will ſhiver it to pieces. When Mr Bulfinger ſays that a moderate blow will break a diamond which could carry a mountain, he not only ſays a thing of which he cannot demonſtrate the truth, and which, in all probability, is not true; but he omits noticing a circumſtance which he was mechanician enough to know would have a conſiderable ſhare in the effect. We mean the rapidity with which the excited preſſure increaſes to its maximum in the caſe of a blow. In the experiment in queſtion, this happens in leſs than the millionth part of a ſecond, if the velocity of the hammer has been ſuch as a man would generate in it by a very moderate exertion. For the blow which will drive a good lath nail to the head in a piece of ſoft deal with an ordinary carpenter's hammer, muſt be accounted moderate. This we have learned by experiment to be above 25 feet per ſecond. The connecting forces exerted between the particles of the diamond may not have time ſufficient for their excitation in the remote parts, ſo as to ſhare the derangement among them all, in ſuch a manner that it may be ſo moderate in each as not to amount to a diſunion in any part of the diamond. We ſee many inſtances of this in the abrupt handling of bodies of tender and friable texture. It is partly owing to this that a ball diſcharged from a piſtol will go through a ſheet of paper ſtanding on edge without throwing it down, which it would certainly do if thrown at it by the hand. The connecting forces, having time to act in this laſt caſe, drag the other parts of the paper along with them, and their union is preſerved. Alſo, when a great weight is laid on the diamond, it is gradually dimpled by it; and thus incloſing many parts together in the dimple, it obliges them to act in concert, and the derangement of each is thus diminiſhed.

We flatter ourſelves that the preceding obſervations and reflections will contribute ſomewhat towards removing the paradoxes and myſteries which diſcredit, in ſome degree, our mechanical ſcience. If we will not pertinaciouſly conjure up ideal phantoms, which, perhaps, *cannot* exiſt, but content ourſelves with the ſtudy of that tangible matter which the Author of Nature has preſented to our view, we ſhall have abundant employment, and ſhall perceive a beautiful harmony thro' the whole of natural operations; and we ſhall gradually diſcover more and more of thoſe mutual adaptations which enable an atom of matter, although of the ſame preciſe nature wherever it is found, to act ſuch an unſpeakable variety of parts, according to the diverſity of its ſituations and the ſcene on which it is placed. If a mind be "not captivated by the harmony of ſuch ſweet ſounds," we may pronounce it, "dark as Erebus, and not to be truſted."

PERFECT Number, is one that is equal to the ſum of all its aliquot parts when added together. Eucl. lib. 7, def. 22. As the number 6, which is $= 1 + 2 + 3$, the ſum of all its aliquot parts; alſo 28, for $28 = 1 + 2 + 4 + 7 + 14$, the ſum of all its aliquot parts. It is proved by Euclid, in the laſt prop. of book the 9th, that if the common geometrical ſeries of numbers 1, 2, 4, 8, 16, 32, &c. be continued to ſuch a number of terms, as that the ſum of the ſaid ſeries of terms ſhall be a prime number, then the product of this ſum by the laſt term of the ſeries will be a perfect number.

PERGUNNA, in Bengal, the ſubdiviſion of a diſtrict.

PERKINISM, the proper name of what we muſt think an impoſition attempted to be put upon the world by Dr Perkins of North America.

Though the phenomena of electricity had been long familiar to the philoſophers of Europe, it is well known that a philoſophical theory of theſe phenomena was firſt formed by a tranſatlantic philoſopher. In like manner, though the diſcovery of Galvani, under the name of *animal electricity* (ſee Galvanism in this *Supplement*), had occupied the attention of many of the firſt phyſicians and philoſophers of the old world, it was reſerved for a phyſician of the new, to apply it to the cure of a number of diſeaſes. Every philoſopher of America, however, has not the ſagacity of the Philadelphian ſage; nor muſt Dr Perkins or his admirers be ſurpriſed, if we treat not incomprehenſible myſticiſm with the reſpect due to a theory founded on facts.

We are told by the son (A) of this rival of Franklin, that before the news of Galvani's discovery had reached America, he had observed several phenomena pointing out the influence of metals in cases of pain. The first remarkable incident that presented itself to his notice was the sudden contraction of a muscle when he was performing a chirurgical operation. This, he observed, regularly took place whenever the point of the metallic instrument was put in contact with the muscle. Struck with the *novelty* of the appearance (Is Mr Perkins sure that the appearance was new?), he was induced to try the points of wood and other substances; and no contraction taking place on these experiments, he thence inferred that the phenomena could be ascribed only to the influence of the metal. About the same time, he observed that, in one or two cases (and if his practice had been great he might have observed that in a thousand cases), a cessation of pain had ensued when a knife or lancet was applied to separate the gum from a tooth previous to extracting it; and in the same year he discovered, that *momentary* ease was given, in a few instances, by the accidental application of a metallic instrument to inflamed and painful tumors previous to any incision.

These are the judicious reasonings and assertions of a dutiful child, who, having probably heard of Leibnitz's claims to some of Newton's discoveries, was determined to put in a similar claim for his father, to a *share*, at least, of the discovery made by the celebrated professor at Bologna. He has not, however, copied with servility the conduct of the Leibnitzians. We do not remember an instance where any of them attempted to elevate the fame or the merits of their master *above* the fame and merits of Newton; but, according to our author, the pursuits of Galvani and his European pupils sink into insignificance, when compared with those of the transatlantic physician.

This is evident; for when the physiologists of Europe were engaged in experimenting on the denuded nerves and muscles of the smaller animals, with a view to ascertain the agency of this incomprehensible property in them, Dr Perkins was prosecuting a series of experiments, which consisted in applying externally, to parts affected with disease, metals, and compounds of metals of every description which occurred to him, and constructed into various forms and sizes. The result proved, that on drawing lightly over the parts affected certain instruments, termed *tractors*, which he formed from metallic substances into pointed shapes, he could remove most of those topical diseases of the human body, where an extra degree of nervous energy or vital heat was present; unless such disease was situated in some of the internal viscera, too remote from the part where the instruments could be applied.

The diseases which have been found most susceptible of the influence of the tractors are, rheumatism, some gouty affections, pleurisy, opthalmias, erysipelas, violent spasmodic convulsions, as epileptic fits and the locked jaw, the pain and swelling attending contusions, inflammatory tumors, the pains from a recent sprain, the painful effects of a burn or scald, pains in the head, teeth, and indeed most kinds of painful topical affections, excepting where the organic structure of the part is destroyed, as in wounds, ulcers, &c. and excepting also where oils or some other non-conducting substances are present.

But we have other testimonies than those of Dr Perkins and his son for the influence of the tractors. Mr Meigs, professor of natural philosophy at Newhaven, in a letter on Dr Perkins's discovery, conceives the principles of metallic irritability as so little understood, that he will not pretend to explain how the tractors produce their effects; but seems satisfied in finding that the effects are produced. After stating an experiment on his own child, eight years of age, very dangerously ill with a peripneumonic complaint, and to which the tractors gave almost instantaneous relief, he says, "I have used the tractors with success in several other cases in my own family; and although, like Naaman the Syrian, I cannot tell why the waters of Jordan should be better than Abana and Pharpar, rivers of Damascus; yet, since *experience* has proved them so, no reasoning can change the opinion. Indeed, the causes of all common facts are, *we think*, perfectly well known to us; and it is very probable, fifty or an hundred years hence, we shall as well know why the metallic tractors should in a few minutes remove violent pains, as we now know why cantharides and opium will produce opposite effects: viz. we shall know but *very little* about either, excepting *facts*."

Mr Woodward, professor of natural philosophy at Dartmouth, in a letter also on the same subject, has stated a number of successful experiments in pains of the head, face, teeth, and in one case of a sprain.

Dr Vaughan, a member of the Philadelphia medical society, has lately published an ingenious tract on Galvanism, the object of which is to account for the influence of the tractors in removing diseases. After a citation of numerous experiments made on the nerves and muscles of animals, he observes, "If we only take an impartial view of the operations of Nature herself, and attend diligently to the analytical investigations of the aforementioned experimentalists on this sublime subject, I think the sceptic must admit that the principle of nervous energy is a modification of electricity. As sensation is dependant on this energy, a pleasurable sensation, or what may be termed a natural or healthy degree thereof; then certainly pain, or supersensation, can only depend on an accumulation of the electric fluid, or extra degree of energy in the part affected. On this principle the problem admits of easy solution; namely, that the metals, being susceptible of this fluid, conduct the extra degree of energy to parts where it is diminished, or out of the system altogether, restoring the native law of electric equilibrium."

We trust we are not sceptics; and yet we feel not ourselves inclined to admit any part of this theory. We have seen no proof that nervous energy is a modification of electricity; and we think that we have ourselves proved, that *galvanism* and *electricity* are in many respects different; but we shall not be much surprised if we soon see a *demonstration* by some American or German philosopher,

(A) See a pamphlet, entitled The Influence of Metallic Tractors on the Human Body, &c. by Benjamin Douglas Perkins, A. M. son to the discoverer; or a very good abridgement of it in the first volume of the Philosophical Magazine.

Perkinism. philosopher, that the foul of man is a compofition of filver and zinc. One of thefe fages has lately difcovered, that the fymptoms of *putrefaction* do not conftitute an *infallible* evidence of death, but that the application of *metals* will in all cafes afcertain it beyond the poffibility of doubt! A proper application certainly will; for when the Perkinift is doubtful whether his patient be dead or alive, he has only to apply the muzzle of a loaded piftol to his temple, and blow out his brains; after which he may fafely fwear that the man is dead.

From the *Philofophical Magazine*, we learn that Profeffor Schumacher at Copenhagen made experiments with tractors of brafs and iron on ten patients in Frederick's hofpital at Copenhagen. He tried alfo tractors of ebony and ivory, which are faid to have cured a pain in the knee; with others of filver and zinc; and fome of copper and lead. By the two laft, pains in the knee, arm, and face, are faid to have been mitigated. According to M. Klingberg's experiments, this remedy was of ufe in *malum ifchiaticum*; and according to thofe of M. Steffens, in *malum ifchiaticum* and megrim. According to M. Bang, the pains in fome cafes were increafed, and in others allayed. According to M. Blech, the tractors were of ufe in *hemicrania* and gouty pains in the head; and, according to M. Hahn, in rheumatic pains in both fhoulders. The principal document in the Danifh collection relating to Perkinifm, appears to be a letter of Profeffor Abilgaard, in whofe opinion Perkins's tractors will never acquire much value in medicine, and fcarcely even have the merit of being a palliative; but, in a phyfical point of view, he thinks they deferve the attention of phyficians, and particularly of phyfiologifts. Mankind (he fays) hitherto have paid too little attention to the influence which electricity has on the human body; otherwife they would know that the effects produced on it by our beds is no matter of indifference. If the feather beds and hair mattreffes, &c. are perfectly dry, the perfon who fleeps on them is in an infulated ftate; but the contrary is the cafe if they are moift. He three times removed a pain in the knee, by fticking the tractors, one on each fide of the knee, fo deep through the ftockings that the points touched the fkin. He removed a rheumatic pain in the head from a lady by the fame means. M. Kafn, by the tractors, relieved, in others, gouty pains of the head and megrim: and in himfelf, a rheumatic pain of the back, which, according to his fenfations, was like a conftriction in the cellular tiffue. M. Herholdt, from his experiments, confiders the effect of the tractors as indefinite and relative as that of other remedies. He, however, faw relief given by them in the ftrangury in a cafe of fyphilis. M. Bang alfo, at Soroe, freed a man from a violent gouty pain in the thigh, by drawing the tractors 200 times over the affected part. M. Jacobfen likewife found benefit derived from thefe tractors feveral times in the common hofpital at Copenhagen. M. Tode tried them alfo in rheumatic pains, toothe-ache, and inflammation of the eyes; and obferved that they neither did good nor harm.

On fome of the attefted cures mentioned in Mr Perkins's pamphlet, an able writer in the Monthly Review has made remarks fo very pertinent, that we cannot refufe ourfelves the pleafure of tranfcribing them.

"At page 54 of the pamphlet, we meet (fays the reviewer) with a ftrong proof of the confidence placed in this remedy by feveral tranfatlantic philofophers. Dr Willard, it feems, applied a red hot piece of iron to a wart on his finger, and burnt himfelf very feverely, in order that he might be relieved by the tractors; which are faid to have given him eafe in two fucceffive experiments. The author adds, 'many have fubmitted to fimilar meafures, in order to *experience* the effects. I once formed one of five, who burned ourfelves fo that blifters were raifed, to make the experiment; we all obtained relief in a few minutes.'

"This zeal for knowledge is truly edifying; efpecially as the tractors are generoufly prefented to the public at *only* five guineas a pair; and it is clear that one pair would fuffice to cure all the burns and fcalds of a large parifh. Why are not fuch luculent experiments repeated here? If Mr Perkins, or any admirer of the difcovery, would fubmit to have a red hot poker run into fome part of his body not neceffary to life (into *that part where honour's lodged*, according to Butler, for example), in any public coffee houfe within the bills of mortality, and would afterward heal the wound in prefence of the company, in ten minutes, or in half as many hours, by means of the tractors, the moft ftony-hearted infidel could not refift fuch a demonftration. Why trifle with internal inflammations, when fuch an outward and vifible fign might be afforded?

"Mr Perkins has taken fome pains, in the firft part of his pamphlet, to fhew that the operation of his rods is not derived from animal magnetifm. In our opinion, this is an unneceffary piece of trouble in England, where there is a conftant fucceffion of fimilar pretenfions. The *virgula divinatoria*, and the *laguette* of the juggler, are the genuine prototypes of this myftery. We were, indeed, rejoiced, on Dr Perkins's account, to find that the Connecticut Society had only denounced him as a Mefmerift: we trembled left he fhould have been put into the inquifitorial hands of the old women as a white witch."

This may be thought too ludicrous a treatment of a difcovery which profeffes to benefit mankind; but to have treated this difcovery with ferioufnefs, would have degraded the profeffion of a fcientific critic. As if the very cures pretended to have been performed did not of themfelves throw fufficient ridicule over the difcovery, Mr Perkins informs us, "that in fome inftances the metallic influence, when excited by different perfons, produces different effects. Experiments made to afcertain the point, proved that there were perfons who might ufe the tractors for any length of time, in difeafes which were fuitable for the operation, and produce no perceptible effect; when by placing them in the hands of another perfon, who fhould perform the operation precifely in the fame manner as before, the pain or inflammation would be removed directly." Hence he endeavours to prove that the influence of the tractors is Galvanic, by an argument as abfurd as the pretended fact on which it is founded.

"On the application (fays he) of zinc and filver to the tongue, the fenfation of tafte is very flight to fome, while with others it is very ftrong:—when the experiment is applied to the fenfe of fight, fome are hardly fenfible of it, while others obferve a ftrong flafh." But, not to mention that neither ebony nor ivory can form part of the excitatory arc in *Galvanifm*, though we have

Perkinifm. have feen them both employed *fuccefsfully* as tractors by a Danifh Perkinift, it is enough to obferve, that the different effects of the Galvanic metals on different perfons depend upon the difference of ftructure of the organs of fenfation in the *patients;* whereas the different effects of the metallic tractors refult, according to this account, from the difference of ftructure in the organs of fenfe of the various *operators!* Nay, what is ftill more extraordinary, if any thing can be more extraordinary than this, is, that the value of the tractors depends, not upon the *materials* of which they are made, or the *fkill* of the manufacturer, but upon fome inconceivable virtue conveyed by Mr Perkins to the *perfon* of him by whom they are *fold.* This we learn from a pamphlet publifhed by Charles Cunningham Longworthy, furgeon in Bath; who informs us, that he fells tractors by *commiffion* from Mr Perkins the original manufacturer in London.

After this article was fent to the prefs, and thus much of it printed, we received, from a friend in London, a copy of Mr Perkins's laft publication on the fubject *; in which he endeavours to repel the objections urged by Dr Haygarth and others againft the influence of the metallic tractors. Had we not been previoufly convinced of the falfity of Perkinifm, the perufal of this pamphlet would have removed from our minds every doubt; for we will venture to fay, that it is not in the power of Dr Haygarth, and the whole faculty united, to bring more complete proof than Mr Perkins has here brought, that what he calls his father's *difcovery* has no claim to rank otherwife than with the difcovery of Mefmer. See *Animal* MAGNETISM, Encycl.

* *The Efficacy of Perkins's Patent Metallic Tractors, &c.* 1800.

He gives indeed 250 cafes, which are attefted to have been fuccefsfully treated by the tractors; but at leaft an equal number of cafes were attefted to have been fuccefsfully treated by Mefmer and his partifans; and fix times that number of cures were faid to have been miraculoufly performed at the tomb of the Abbé Paris (See PARIS in this *Suppl.*) We would willingly allow, however, that thefe atteftations ought to draw the attention of men of fcience to the fubject, did not the author himfelf betray a want of confidence in the tractors, by his own arguments in their favour, and by his caution to the public againft *counterfeits.* He feems indeed to confider their fanative influence as refulting entirely from his *patent.*

Dr Haygarth having faid that he performed cures of the fame kind with thofe of which Mr Perkins boafts, by the proper application of tractors made of *wood;* and having added, that "if any perfon would repeat thefe experiments, it fhould be done with due folemnity," in order to work upon the imagination; our author replies, by putting the following queftion: "Is there a fingle poffeffor of the *patent metallic* tractors in England, who has frequently ufed them, and will fay that this fraud is neceffary to make *them* perform *cures?*" Inftead of anfwering for the Englifh poffeffors of thefe valuable inftruments, we beg leave, in our turn, to afk, If there be a fingle expert chemift in Great Britain who can underftand this queftion in any other fenfe than as implying that the virtue of the tractors refides in the *patent?* This, however, appears ftill more palpable in the caution to the public.

"Among the various artifices (fays Mr Perkins) which have been employed by certain interefted perfons, I have to mention the mean attempt to circulate *falfe tractors,* and from the failure of thefe to throw difcredit upon the difcovery. Three inftances of this kind have occurred lately. Complaints having been made to me that my tractors would not cure the difeafes for which they are recommended, I was led to make inquiry refpecting the cafes alluded to; and conceiving them fit fubjects for the tractors, I called on the patients to apply them myfelf. In *both* inftances (it was juft now in *three* inftances) I found they had been ufing *counterfeit* tractors. Had not this been difcovered, the *merit* of the *patent* tractors muft have fuffered extremely!"

This is very extraordinary. The *character* or *fame* of any thing may indeed be injured by a counterfeit; but we believe this is the firft inftance of the *merit* or *demerit* of one inanimate fubftance being increafed or diminifhed by another at a diftance from it,—of the hardnefs of fteel, for inftance, being diminifhed by the foftnefs of lead! But we beg Mr Perkins's pardon. The *merit* of his tractors confifts in their putting money into his pocket; and *that* merit might certainly be injured by the ufe of *counterfeits.* Hence, with great propriety, he informs the public, that every *genuine fet* is ftamped with the words PERKINS's PATENT TRACTORS, accompanied with a receipt for the five guineas, numbered and figned in the handwriting of the patentee. From thefe facts we infer (and he muft acknowledge the inference to be juft), that the virtue of the tractors refides in the *patent,* reftricting the making of them to *Benjamin Douglas Perkins,* and not to the *metal* of which they are made. This is indeed moft obvious; for he cannot be fuch a ftranger to the ftate of chemical fcience in this country, as to fuppofe that his tractors may not be analyfed into their component principles, and, of courfe, that others may not be made poffeffing all their virtues except fuch as refult from the patent.

We fhall conclude this article in the words of the reviewer already quoted: "To trace the relations and dependencies of projects fimilar to that of Dr Perkins, would now be a work of more labour than utility. The fund of public credulity is an inexhauftible refource for thofe who can refolve to levy contributions on it. In vain is the fpirit of quackery exorcifed in one form; it rifes again immediately, 'with twenty ghaftly murders on its head, to pufh us from our ftools.' We, who have contemplated the progrefs of real knowledge during a long courfe of years, have feen many bubbles like this glitter for a moment, and then difappear for ever. People may talk of Mefmerifm, or Perkinifm, but we confider all fuch varieties as belonging to the old and extenfive clafs of Charlatanifm."

Perouse.

PEROUSE (John Francis Galoup de la), the celebrated, though unfortunate, French navigator, was born at Albi in 1741. Of the rank or condition of his father, M. *Milet-Mureau* has given us no information in that meagre eulogy of Peroufe which he has inferted in the introduction to his laft voyage. It appears, however, that he intended to make his fon a feaman, and fent him, at a very early period of life, to the marine fchool, where the young man became enthufiaftically fond of his profeffion, and laudably ambitious to emulate the fame of the moft celebrated navigators.

Being

Being appointed a midfhipman on the 19th of November 1756, he behaved, we are told, with great bravery in that ftation, and was feverely wounded in the engagement between the admirals Hawke and Conflans, on the 20th of November 1759. The Formidable, in which he ferved, was taken, after a vigorous refiftance; and it is probable that Peroufe reaped fome advantage from his acquaintance with Britifh officers.

On the 1ft of October 1764 he was promoted to the rank of lieutenant; and defpifing a life of eafe and idlenefs, he contrived to be employed in fix different fhips of war during the peace that fubfifted between Great Britain and France. In 1767 he was promoted to the rank of what, in our navy, is called *mafter* and *commander*. In 1779 he commanded the *Amazone*, belonging to the fquadron of Vice-admiral Count d'Eftaing; and when that officer engaged Admiral Byron, the poft of La Peroufe was to carry his Admiral's orders to the whole of the line. He afterwards took the floop *Ariel*, and contributed to the capture of the *Experiment*—exploits which his eulogift feems to confider as inftances of very uncommon heroifm; but he foon after performed a greater.

Being, on the 4th of April 1780, appointed captain of the frigate *Aftrea*, and being on a cruife with the *Hermione*, thefe two frigates attacked fix Englifh veffels of war, of from 28 to 14 guns each, and took two of them. The French certainly reaped more laurels about that period than they have been accuftomed to do in naval wars with Great Britain: but as we have completely forgotten the particulars of this fight, we fufpect that it was not altogether fo very brilliant a bufinefs as M. Milet-Mureau is pleafed to reprefent it.

In the year 1782, La Peroufe was difpatched with the Sceptre of 74 guns, and two frigates of 36 guns each, having fome troops and field pieces on board, to deftroy the Englifh fettlements in Hudfon's Bay. This tafk was eafily accomplifhed; for when he had furmounted the difficulties of navigation in a frozen fea, he found nothing on fhore to oppofe the fmalleft force. Having deftroyed the fettlements, he learned that fome of the Englifh had fled at his approach into the woods; and his eulogift confiders it (fuch are the difpofitions of French republicans) as a moft wonderful inftance of humanity, that he left to thefe unfortunate men provifions to preferve them from perifhing by hunger, and arms to protect them from the fury of the favages! Peroufe, we dare anfwer for him, was confcious of nothing heroic or extraordinary in this act of beneficence, which he certainly could not have omitted, without incurring both infamy and guilt.

In the year 1785, he was appointed to the command of a voyage round the world; which was unfortunately deftined to be his laft. Of this voyage, as far as it was accomplifhed, there is a full account in the hands of every French and Englifh reader; and from that account it appears, that Peroufe was admirably qualified to difcharge fuch a truft. He feems to have been an experienced and fkilful feaman; a man of confiderable mathematical and phyfical fcience, uncorrupted by that philofophifm which difgraced many of his attendants; and capable of the utmoft perfeverance in every laudable purfuit. To thefe qualities he united a proper combination of caution and courage, with a difpofition truly benevolent to the various tribes of favages whom he vifited. The difafters which occurred on the voyages were all, except the laft, of which nothing is known, occafioned by the difobedience of his officers, or their neglecting to follow his advice.

The laft difpatches of this great and good man were dated from Botany Bay, February the 7th, 1788; and fince that period, no account of him has been received which is intitled to the fmalleft confidence. *M. Milet-Mureau* has indeed given us, at fome length, the childifh conjectures of the Society of Natural Hiftory refpecting his fate, which, in language equally childifh, were delivered at the bar of the National Affembly; and he has added the ridiculous decree which that body of legiflative fciolifts paffed in confequence of fo extraordinary a fpeech. We will not difgrace our pages, or infult the memory of Peroufe, by contributing to the circulation of nonfenfe, which, we are perfuaded, would have made him blufh for his country.

PERPENDICULAR, in gunnery, is a fmall inftrument, ufed for finding the centre line of a piece in the operation of pointing it to a given object.

PERSIAN or PERSIC, in architecture, a name common to all ftatues of men, ferving inftead of columns to fupport entablatures.

PERWANNAH, in the language of Bengal, an order of government, or a letter from a perfon in authority.

PETERSBURGH (St), the capital of Ruffia, is a city, of which a pretty full hiftorical detail has been given in the *Encyclopædia*. It is introduced here merely on account of its police, which, according to the anonymous author of the life of Catharine II. has a very fimple and competent organization, and deferves to be adopted in other great capitals. Excepting the governor, whofe office naturally extends to all objects of public welfare, the head police-mafter is the proper chief of the whole fyftem of police. His office takes in the great compafs of this department, but confined to the general objects of public fecurity and order. He is not here, as in fome large towns, the formidable copartner of family fecrets, and the invifible witnefs of the actions of the private man. Under the head police-mafter is the police-office, where fit a police-mafter, two prefidents, the one for criminal, the other for civil cafes, and two confulters, chofen from the burgher clafs. To this is committed the care to maintain decorum, good order, and morals: alfo it is its bufinefs to fee to the obfervance of the laws, that the orders iffued by government, and the decifions of the courts of juftice, are put in force. The attainment of thefe purpofes is effected by the following mechanifm:

The refidence is divided into ten departments. Each of thefe has a prefident, appointed to watch over the laws, the fecurity, and the order of his diftrict. The duties and rights of this office are not lefs extenfive than important. A prefident muft have exact knowledge of the inhabitants of his department, over which a fort of parental authority is committed to him; he is the *cenfor morum* of his department; his houfe muft not be bolted or barred by night or day, but muft be a place of refuge, continually open to all that are in danger or diftrefs; he himfelf may not quit the town for the fpace of two hours, without committing the difcharge of his office to fome other perfon. The police-commando (conftables), and the watchmen of his department, are under

under his orders; and he is attended on all affairs of his office by two ferjeants. Complaints againft unjuft behaviour in the prefident may be brought to the police-office.

Each department is again divided into three, four, or five fubdivifions, called quarters, of which, in the whole refidence, are 42. Each of thefe has a quarter-infpector, in fubordination to whom is a quarter-lieutenant. The duty of thefe police-officers is in harmony with that of the prefident, only that their activity is confined to a fmaller circle. They fettle low affairs and flight altercations on the fpot, and keep a watchful eye on all that paffes.

The number of the nightly watch in the city amounts to 500. They have their ftations affigned them in watch-houfes at the corners of ftreets; and, befides their proper deftination, are to affift in the taking up of offenders, and in any fervice, by day or night, as their commanders fhall require. Befides thefe, for the execution of the police orders, and to act as patroles, there is alfo a commando of 120 men, who, in cafes of emergency, are fupported by a company of kofaks, or a regiment of huffars.

This machine, confifting of fo many fubordinate parts, preferves in its orderly courfe that fecurity and peace which excite the admiration of all foreigners. The activity of every individual member is unobferved in the operation of the whole; and by fuch a diftribution alone is the attainment of fo complicated an aim practicable.—All the quarter-infpectors of a department repair every morning, at feven o'clock, to their infpector's houfe, to lay before him the report of all that has happened in their quarters during the laft 24 hours; and at eight o'clock, all the infpectors bring together thefe feveral reports into the police-office, whereupon they firft and immediately take into examination the cafes of perfons taken into cuftody during the night. On urgent occafions, the police-office affembles at all hours.

This organization, and the extraordinary vigilance of the police, which is found competent to the bufinefs of a numerous and reftlefs people, render all fecret inquifitions unneceffary. The police has knowledge of all perfons in the refidence; travellers who come and go are fubject to certain formalities, which render it extremely difficult to conceal their place of abode, or their departure from the city. To this end, every houfeholder and innkeeper is obliged to declare to the police who lodges with him, or what ftrangers have put up at his houfe. If a ftranger or lodger ftays out all night, the landlord muft inform the police of it at lateft on the third day of his abfence from his houfe. The cautionary rules, in regard to travellers quitting the town, are ftill more ftrict. Thefe muft publifh in the newfpapers their name, their quality, and their place of abode, three feveral times, and produce the newfpapers containing the advertifement, as a credential in the government from which they then received their paffport; without which, it is next to impoffible to get out of the empire. This regulation not only fecures the creditor of the perfon about to depart, but alfo enables the police to keep a clofer infpection over all fufpected inhabitants.

If individuals may be fufpected by the government, becaufe their means of fupport, the company they keep, and their whole courfe of action, are clofely wrapped up in myftery; fo likewife may whole focieties be lefs indifferent to it, if they carefully conceal the object of their connection, or their very exiftence, from the eye of the public. The police watches here, with laudable attention, over fecret focieties of all kinds; and frequently as the fanatical fpirit of religious or political fectaries, or the enthufiafm of pretended myftagogues, have attempted to neftle here, they have never been able to proceed, or only for a very fhort time. Animal magnetifm, Martinifm, Rofycrutianifm, and by whatever other name the conceits of diftempered imaginations may be called, have always been attended with the fame bad fuccefs on this ftage.

From this fketch it will be readily imagined, that the number of impoftors and difturbers of the public peace can be but fmall. Quarrels and affrays in the ftreets or in the cabaks but feldom happen. The perfon attacked calls the neareft watchman; and in a moment both the aggreffor and the aggrieved are taken into cuftody, and led to the next fieja (police-watch-houfe), where the caufe of their quarrel is inquired into, and the aggreffor is punifhed. For matters of fome defcriptions, there is a peculiar tribunal, under the denomination of the oral court, which, on account of its fingularity, deferves to be briefly noticed.

In each quarter of the town are one or more judges of the oral court, who are chofen from the clafs of burghers, and with whom are affociated a few jurats. This court fits daily in the forenoon, and proceeds orally in all the differences that come before it. It, however, keeps a day-book, in which are entered all the caufes and decifions of the court, and which muft be every week laid before the magiftrate. When a charge is brought, the court declares it orally to the prefident of the quarter: whereupon the accufed muft not delay his appearance before the police longer than one day after he has received the fummons. Every caufe muft be determined in one day, or, if the examinations require more time in collecting, in three days. The oral court communicates the decifion to the prefident of the quarter by means of his day-book, in order to its ratification. If either party is not fatisfied with the fentence, he may appeal to the court as appointed in the regulations.

This is a very favourable account of the police of St Peterfburgh; but it is differently reprefented in *Beaujolin's Travels of two Frenchmen through Ruffia*, in 1790—1792. According to him, the police of the capital of that empire is far from being on the moft refpectable footing. There happen, indeed, but few accidents in the night; yet fometimes murders are committed, and efpecially thefts; for which, according to our author, it is exceedingly rare to obtain juftice. When a perfon has been affaffinated in fome place of bad repute, the police-officer is engaged to fecrecy by means of a few rubles; fo that the affair is foon hufhed up, unlefs the deceafed belonged to fome powerful family, whofe intereft makes it neceffary that inquiries fhould be inftituted. When two perfons quarrel, either in the ftreet or in a public houfe, he who *pays* the inquirer is always in the right: the inferior police-officers are never proof againft money; and the *poor* individual, whether he be in the right or wrong, is almoft fure of a beating.

PETIVER (James), a famous Englifh botanift, was con-

Petiver, Phasianus.

contemporary with Plukenet; but the exact time of his birth is not known, nor is much intelligence concerning him at present to be obtained. His profession was that of an apothecary, to which he was apprenticed under Mr Feltham, then apothecary to St Bartholomew's hospital *. When he entered into business for himself, he settled in Aldersgate street, and there continued for the remainder of his life. He obtained considerable business, and after a time became apothecary to the charter-house. After the Tradescants, he appears to have been the only person, except Mr Courten and Sir Hans Sloane, who made any considerable collection in natural history, previous to those of the present day. He engaged the captains and surgeons of ships to bring him home specimens, and enabled them to select proper objects, by printed directions which he distributed among them. By these means his collection became so valuable, that some time before his death Sir Hans Sloane offered him L. 4000 for it. After his death, it was purchased by the same collector. His museum extended his fame both at home and abroad. He was elected into the Royal Society; and becoming acquainted with Ray, assisted him in arranging the second volume of his History of Plants. He died April 20. 1718; and much honour was shewn to him at his funeral, by the attendance of Sir Hans Sloane, and other eminent men, as pall bearers, &c. By future botanists, his name was given to a plant. See PETIVERIA, *Encycl.*

* Pulteney's *Sketches of Botany in England.*

He gave the world several publications on various subjects of natural history: 1. *Musci Petiveriani Centuriæ decem*, 1692—1703, 8vo. 2. *Gazophylacii Naturæ et Artis, Decades decem*, folio, 1702, with 100 plates. 3. A Catalogue of Mr Ray's English Herbal, illustrated with figures, folio, 1713, and continued in 1715. 4. Many small publications, which may be found enumerated in Dr Pultney's book. 5. Many papers in the Philosophical Transactions, and a material article in the third volume of Ray's work, entitled, *Plantæ Rariores Chinenses Madraspatanæ, et Africanæ, a Jacobo Petivero ad opus Consummandum Collatæ*, &c. Many of his smaller tracts having become very scarce, his works were collected and published, exclusive of his papers in the Transactions, in 2 vols folio, and one 8vo, in the year 1764.

PHASIANUS (See *Encycl.*) A species of this genus of birds, formerly not described, was sent from Batavia to England by Lord Macartney, or some of his attendants, when they were on their voyage to China. The species to which it seemed to be most nearly allied, in point of general habit or appearance, was the *phasianus curvirostris*, or Impeyan pheasant; an East Indian bird, described and figured both in Mr Latham's Ornithology, and in the Museum Leverianum. From that bird, however, it differs very considerably. The tail of the latter being in a mutilated state, it was scarce possible to determine, with absolute precision, whether it should be referred to that subdivision of pheasants which contains those with long or cuneiform tails, or those with rounded ones, as in the Impeyan pheasant. The general colour of this most elegant bird was black, with a gloss of blue, or what, in the language of natural history, may be termed chalybean black, or black accompanied by a steel blue lustre. The lower part of the back was of a peculiarly rich colour, which, according to the different directions of the light, appeared either of a deep ferruginous or of the brightest fiery orange red. This beautiful colour passed in the manner of a broad zone round the whole body; but on the abdomen was of a much more obscure appearance than on the back, as well as somewhat broken or irregular, especially on the sides. The throat was furnished with a large, and somewhat angular, pair of wattles, uniting with the bare spaces on the cheeks. The feathers on the top of the head, which was of a lengthened form, ran a little backward, so as to give the appearance of an indistinct occipital crest. The beak was remarkable for a more lengthened and curved aspect than in any other bird of this genus, except the Impeyan pheasant. The feathers on the neck, back, and breast, were rounded, and of the same shell-like or scaly habit as those of the turkey. The legs very stout, and were armed with a pair of extremely strong, large, and sharp spurs. Both legs and beak were of a pale colour. Whether this bird be really new or not to the ornithologists of Europe, it may at least be affirmed with safety, that it had never been properly described; nor can the character of any species, hitherto introduced into the books of any systematic naturalist, be considered as a just or competent specific character of the present bird. It may be called the *fire-backed pheasant*; and its essential character may be delineated in the following terms: Black pheasant with a steel-blue gloss; the sides of the body rufous; the lower part of the back fiery ferruginous; the tail rounded; the two middle feathers pale yellow brown.—*Sir George Staunton's Account of an Embassy to China*, &c.

Phasianus, Philosophist.

PHILOSOPHIST, a lover of sophistry or false reasoning, in contradistinction to *philosopher*, who is a lover of sound reasoning, true science, and practical wisdom.

CRITICAL PHILOSOPHY.

1 Origin of the science.

CRITICAL PHILOSOPHY, is the appellation given to a system of science, of which the founder is *Immanuel Kant*, regius professor of logic and metaphysics in the university of Koenigsberg. Of this system, which is very generally admired in Germany, we promised, in our prospectus, to gratify our speculative readers with a short view; and that promise we are enabled to fulfil, by the kind communication of an illustrious foreigner, who, after acting a conspicuous part on the theatre of the world, and striving in vain to stem the torrent of democratic innovation, is now living an exile from his wretched country, and cultivating the sciences and the arts of peace.

2 Obscurity of its language.

"To explain (says he) the philosophy of Kant in all its details, would require a long and a painful study, without producing any real advantage to the reader. The language of the author is equally obscure, and his reasonings equally subtle, with those of the commentators of Aristotle in the 15th century.

The truth of this assertion will be denied by none, who

who have endeavoured to make themfelves mafters of the works of *Willich* and *Nitfch* on the critical philofophy; and the fource of this obfcurity feems to be fufficiently obvious. Befides employing a vaft number of words of his own invention, derived from the Greek language, Kant ufes expreffions, which have long been familiar to metaphyficians, in a fenfe different from that in which they are generally received; and hence a large portion of time is requifite to enable the moft fagacious mind to afcertain with precifion the import of his phrafeology.

The difficulty of comprehending this philofophy has contributed, we believe, more than any thing elfe, to bring it into vogue, and to raife the fame of its author. Men are afhamed, after fo laborious and fatiguing a ftudy, to acknowledge that all their labour has been thrown away; and vanity prompts almoft every man to raife the importance of that branch of fcience which is underftood but by a few, and in which he is confcious that his own attainments have been great. "We acknowledge, however, that in the fyftem of Kant there is difplayed much genius, combination, and fyftematic arrangement; but this only affords one of the many reafons which it prefents, for our regretting that the author has not directed his mind to more ufeful refearches, and that he has wafted the ftrength of his genius in rendering uncertain the moft comfortable truths, and in giving the appearance of novelty to opinions for the moft part taught long before his day.

The following analyfis, we believe, will fufficiently enable any one, at all converfant with metaphyfical fcience, to form a judgment of this celebrated fyftem; and our correfpondent, on whofe word the reader may rely, affures us, that, in detailing the principles of Kant, he has taken fpecial care to exhibit them with the utmoft poffible exactnefs, having feveral times preferred the obfcurity of the author's reafonings and language, to the danger of a falfe, though more perfpicuous, interpretation.

3 Divifion of human knowledge.

"Kant divides all our knowledge into that which is *a priori*, and that which is *a pofteriori*. Knowledge *a priori* is conferred upon us by our nature. Knowledge *a pofteriori* is derived from our fenfations, or from experience; and is by our author denominated *empyric*. One would at firft be induced, by this account of the origin of human knowledge, to believe that Kant intended to revive the fyftem of *innate ideas;* but we very quickly difcover that fuch is not his fyftem. He confiders all our knowledge as acquired. He maintains, that experience is the *occafional caufe* or *productrice* of all our knowledge; and that without it we could not have a fingle idea. Our ideas *a priori*, he fays, are produced *with* experience, and could not be produced *without* it; but they are not produced *by* it, or do not proceed *from* it. They exift in the mind; they are the *forms* of the mind. They are diftinguifhed from other ideas by two marks, which are eafily difcerned; *i. e.* they appear *univerfal* and *neceffary;* or, in other words, they admit of no exception, and their *converfe* is impoffible. Ideas which we derive from experience have no fuch characters. We can fuppofe, that what we have feen, or felt, or heard once, we may fee, or feel, or hear again; but we do not perceive any impoffibility in its being otherwife. For inftance, a houfe is on fire in my view: I am certain of this fact; but it affords me no *general* or *neceffary* knowledge. It is altogether *a pofteriori;* the materials are furnifhed by the individual impreffion which I have received; and that impreffion might have been very different.

"But if I take twice two fmall balls, and learn to call twice two *four*, I fhall be immediately convinced, that any two bodies whatever, when added to any two other bodies, will conftantly make the fum of bodies *four*. Experience has indeed afforded me the *opportunity* of acquiring this knowledge; but it has not given it to me; for how could experience prove to me that this truth fhall never vary? Experience muft always be *limited;* and therefore cannot teach us that which is *neceffary* and *univerfal*. It is not experience which difcovers to us, that we fhall always have the furface of the whole pyramid by multiplying its bafe by the third part of its height; or that two parallel lines, extended *in infinitum*, fhall never meet.

"All the truths of pure mathematics are, in the language of Kant, *a priori*. Thus, that a ftraight line is the fhorteft of all poffible lines between two fixed points; that the three angles of a triangle are always equal to two right angles; that we have the fame fum, whether we add 5 to 7 or 7 to 5; and that we have the fame remainder when we fubtract 5 from 10 as when we fubtract 10 from 15—are fo many propofitions, which are true *a priori*.

4 Pure knowledge *a priori*.

"Pure *knowledge a priori*, is that which is abfolutely without any mixture of experience. *Two and two men* make *four men*, is a truth, of which the knowledge is *a priori;* but it is not PURE knowledge, becaufe the truth is particular. The ideas of *fubftance*, and of *caufe* and *effect*, are *a priori;* and when they are feparated from the objects to which they refer (we fuppofe from this or that *particular* object), they form, in the language of Kant, *void ideas* (A) It is our knowledge *a priori*, *i. e.* that knowledge which precedes experience as to its origin, which renders experience poffible (B). Our faculty of knowledge has an effect on our ideas of fenfation analogous to that of a veffel, which gives its own form to the liquor with which it is filled. Thus, in all our knowledge *a pofteriori*, there is fomething *a priori* derived from our faculty of knowledge. All the operations of our minds; all the impreffions which our external and internal fenfes receive and retain, are brought into effect by the *conditions*, the *forms*, which exift in us by the pure ideas *a priori*, which alone render all our other knowledge certain.

5 Time and fpace.

"*Time* and *fpace* are the two effential forms of the mind:

(A) In the language of Lock *abftract ideas*.

(B) In our correfpondent's manufcript, this fentence runs thus: "It is our knowledge *a priori*, or that knowledge which *entirely precedes experience* as to its origin, which experience renders poffible;" but here muft be fome miftake, either by the tranflator or by the amanuenfis. Kant's philofophy is abundantly obfcure and paradoxical; but it furely never entered into his head to reprefent the effect as prior in its origin to the very caufe which alone renders it poffible. The context, too, feems to us to agree better with the meaning of the fentence as we have printed it in the text.

mind: the former for impreſſions received by the internal ſenſe; the ſecond for thoſe received by our external ſenſes. Time is neceſſary in all the *immediate* (perhaps *intuitive*) perceptions of objects; and ſpace in all *external* perceptions.

6 Extenſion. "*Extenſion* is nothing real but as the form of our ſenſations. If extenſion were known to us only by experience, it would then be poſſible to conceive that there might be ſenſible objects without ſpace.

7 Impenetrability, &c. "It is by means of the form *ſpace* that we are enabled, *a priori*, to attribute to external objects *impenetrability*, *diviſibility*, *mobility*, &c.; and it is by means of the form *time* that we attribute to any thing *duration*, *ſucceſſion*, *ſimultaneity*, *permanence*, &c.

8 Origin of arithmetic and geometry. "*Arithmetic* is derived from the form of our internal ſenſe, and *geometry* from that of our external.

9 Unifying power of the mind. "Our underſtanding collects the ideas received by the impreſſions made on our organs of ſenſe, confers on theſe ideas *unity* by a particular *force* (we ſuppoſe energy) *a priori*; and thereby forms the repreſentation of each object. Thus, a man is ſucceſſively ſtruck with the impreſſions of all the parts which form a particular garden. His underſtanding unites theſe impreſſions, or the ideas reſulting from them; and in the unity produced by that unifying act, it acquires the idea of the garden. If the objects which produce the impreſſions afford alſo the *matter* of the ideas (c), then the ideas are *empyric*; but if the objects only unfold the *forms of the thought*, the ideas are *a priori*. The act of the underſtanding which unites the perceptions of the various parts of an object into the perception of one whole, is the ſame with that which unites the attribute with its ſubject.

10 Analytic judgments. "Judgments are divided into two ſpecies; *analytic* and *ſynthetic*. An analytic judgment is that in which the attribute is the mere developement of the ſubject, and is found by the ſimple analyſis of the perception; as *bodies are extended*; *a triangle has three ſides*.

11 Synthetic judgments. "A ſynthetical judgment is that where the attribute is connected with the ſubject by a cauſe (or baſis) taken from the faculty of knowledge, which renders this connection neceſſary: as, *a body is heavy*; *wood is combuſtible*; *the three angles of a triangle are equal to two right angles*. There are ſyntheſes *a priori* and *a poſteriori*; and the former being formed by experience, we have the ſure means of avoiding deception.

"It is a problem, however, of the utmoſt importance, to diſcover how ſynthetic judgments *a priori* are poſſible. How comes it, for example, that we can affirm that all the radii of a circle are equal, and that two parallel lines will never meet? It is by ſtudying the *forms* of our mind that we diſcover the poſſibility of making theſe affirmations. In all objects there are things which muſt neceſſarily be THOUGHT (be ſupplied by thought); as, for example, that there is a *ſubſtance*, an *accident*, a *cauſe*, and certain *effects*.

12 Forms of the underſtanding. "The *forms* of the underſtanding are, *quantity*, *quality*, *relation*, *modality*.

"Quantity, Kant diſtinguiſhes into *general*, *particular*, and *individual*; quality, into *affirmation*, *negation*, *infinite*; relation, into *categoric*, *hypothetic*, and *disjunctive*; and modality, into *problematic*, *certain*, and *neceſſary*. He adds alſo to theſe properties of the four principal forms of the underſtanding, a table of *categories* or fundamental ideas *a priori*.

13 Categories. "Quantity, gives *unity*, *plurality*, *totality*. Quality, gives *reality*, *negation*, *limitation*. Relation, gives *inherence*, *ſubſtance*, *cauſe*, *dependence*, *community*, *reciprocity*, Modality, gives *poſſibility*, *impoſſibility*, *exiſtence*, *nothing*, *neceſſity*, *accident*. Theſe categories can only be applied to experience. When, in the conſideration of an object, we abſtract all that regards ſenſation, there remain only the pure ideas of the underſtanding, or the *categories*, by which a *thing* is conceived as a *thing*.

"Pure reaſon is the faculty of tracing our knowledge *a priori*, to ſubject it to principles, to trace it from its neceſſary conditions, till it be entirely without condition, and in complete unity. This pure reaſon has certain fundamental rules, after which the neceſſary connection of our ideas is taken for the determination of the objects in themſelves;—an illuſion which we cannot avoid, even when we are acquainted with it. We can conclude from what we know to what we do not know; and we give an *objective* reality to theſe concluſions from *an appearance* which leads us on.

14 Critique of pure reaſon. "The writings of Kant are multifarious; but it is in his work entitled the *Critique of Pure Reaſon* that he has chiefly expounded his ſyſtem. This work is a treatiſe on a pretended ſcience, of which Kant's ſcholars conſider him as the founder, and which has for its objects the *natural forces*, the *limits of our reaſon*, as the ſource of our pure knowledge *a priori*, the *principles of all truth*. Kant does not propoſe to give even an expoſition of theſe branches of knowledge, but merely to examine their origin; not to extend them, but to prevent the bad uſe of them, and to guard us againſt error. He denominates this ſcience *tranſcendental criticiſm*; becauſe he calls all knowledge, of which the object is not furniſhed by the ſenſes, and which concerns the kind and origin of our ideas, *tranſcendental knowledge*. The Criticiſm of Pure Reaſon, which gives only the fundamental ideas and maxims *a priori*, without explaining the ideas which are derived from them, can lead (ſays Kant) to a complete ſyſtem of pure knowledge, which ought to be denominated *tranſcendental philoſophy*, of which it (the *Criticiſm*, &c.) preſents the *architectonic* plan, *i. e.* the plan regular and well diſpoſed.

"The work entitled *The Critique of Pure Reaſon*, is divided into ſeveral parts or ſections, under the ridiculous titles of *Æſthetic tranſcendental*; of *tranſcendental logic*; of *the pure ideas of the underſtanding*; of *the tranſcendental judgment*; of *the paralogiſm of pure reaſon*; of *the ideal tranſcendental*; of *the criticiſm of ſpeculative theologies*; of *the diſcipline of pure reaſon*, &c.

15 We cannot know objects as they are in themſelves. "But to proceed with our abſtract of the ſyſtem. We know objects only by the manner in which they affect us; and as the impreſſions which they make upon us are only certain *apparitions* or *phenomena*, it is impoſſible for us to know what an *object is in itſelf*. In conſequence of this aſſertion, ſome have ſuppoſed that Kant is an *idealiſt* like Berkeley and ſo many others, who have thought that ſenſations are only *appearances*, and

(c) This is wonderful jargon; but the reader will reflect that it is not ours.

and that there is no truth but in our reafon; but fuch is not the opinion of Kant (D). According to him, our underftanding, when it confiders the apparitions or phenomena, acknowledges the *exiftence* of the objects in themfelves, inafmuch as they ferve for the bafes of thofe apparitions; though we know nothing of their *reality*, and though we can have no certitude but in experience.

" When we apply the *forms* of our underftanding, fuch as *unity*, *totality*, *fubftance*, *caufality*, *exiftence*, to certain ideas which have no object in *fpace* and *time*, we make a fallacious and arbitrary application. All thefe forms can bear only on fenfible objects, and not on the *world of things in itfelf*, of which we can THINK, but which we CAN NEVER KNOW. Beyond things fenfible we can only have *opinions* or a *belief* of our reafon.

16 Objective and fubjective truths.

" The motives to confider a propofition as true, are either *objective*, *i. e.* taken from an *external* object, fo that each man fhall be obliged to acknowledge them; and then there is a truth *evident* and fufceptible of *demonftration*, and it may be faid that we are *convinced:* or the motives are *fubjective*, *i. e.* they exift only in the mind of him who judges, and he is *perfuaded*.

" TRUTH, then, confifts in the agreement of our *notions* with the *objects*, in fuch a manner as that all men are obliged to form the fame judgment; BELIEF confifts in holding a thing for true in a *fubjective manner*, in confequence of a perfuafion which is entirely perfonal, and has not its bafis in an object fubmitted to experience.

17 Belief.

" There is a *belief of doctrine*, of which Kant gives, as an example, this affertion—' there are inhabitants in the planets.' We muft acknowledge (he adds) that the ordinary mode of teaching the exiftence of God belongs to *the belief of doctrine*, and that it is the fame with *the immortality of the foul. The belief of doctrine* (he continues) has in itfelf fomething *ftaggering*; but it is not the fame with *moral belief*. In moral belief there is fomething *neceffary*; it is (fays he), that I fhould obey the law of morality in all its parts. The end is ftrongly eftablifhed; and I can perceive only one condition, by means of which this end may be in accord with all the other ends, *i. e.* that *there is a God*. I am certain that no man knows any other condition which can conduct to the fame unity of end under the moral law; which law is a law of my reafon. I will confequently believe certainly the *exiftence of God*, and a *future life*; becaufe this perfuafion renders immoveable my moral principles—principles which I cannot reject without

18 Proof of the exiftence of God, &c.

rendering myfelf contemptible in my own eyes. I wifh for happinefs, but I do not wifh for it without morality; and as it depends on *nature*, I cannot wifh it with this condition, except by believing that nature depends on a Being who caufes this connection between morality and happinefs. This fuppofition is founded on the *want* (or *neceffity*) of my reafon, and not on my duty.

" We have, however, no *certainty* (fays Kant) in our knowledge of God, becaufe certainty cannot exift except when it is founded on an object of experience. The philofopher acknowledges, that *pure reafon* is too weak to prove the exiftence of a being beyond the reach of our fenfes. The neceffity of believing in God is therefore only *fubjective*, although neceffary and general for all thofe beings who conform to their duty. This is not *knowlege*, but only a *belief* of reafon, which fupplies the place of a knowledge which is impoffible (E).

" The proofs of natural theology (fays our philofopher) taken from the order and beauty of the univerfe, &c. are proofs only in *appearance*. They refolve themfelves into a bias of our reafon to *fuppofe* an Infinite Intelligence as the author of all that is poffible; but from this bias it does not follow that there really is fuch an Author. To fay, that whatever exifts muft have a caufe, is indeed a maxim *a priori*; but it is a maxim applicable only to experience, for one knows not how to fubject to the laws of our perceptions that which is abfolutely independent of them. It is as if we were to fay, that whatever exifts in experience muft have an experience; but the world, taken as a whole, is without experience as well as its caufe. It is much better to draw the proof of the exiftence of God from morality, than to weaken it by fuch reafoning. This proof is relative. It is impoffible to *know* that God exifts; but we can comprehend how it is poffible to act morally on the *fuppofition* of the exiftence (although incomprehenfible) of an intelligent Creator—an exiftence which PRACTICAL REASON forces THEORETICAL *reafon* to adopt. This proof not only *perfuades*, but even acts on the CONVICTION, in proportion as the motives of our actions are conformable to the law of morality.

" Religion ought to be the *means* of virtue and not its object. Man has not in himfelf the idea of religion as he has that of virtue. The latter has its principle in the mind; it exifts in itfelf, and not as the means of happinefs; and it may be taught without the idea of a God, for the pure law of morality is *a priori*.

" He who does good by inclination does not act morally. The converfe of the principle of morality is to make perfonal happinefs the bafis (F) of the will. There are compaffionate minds which feel an internal pleafure in communicating joy around them, and who thus enjoy the fatisfaction of others; but their actions, however juft, however good, have no moral merit, and may be compared to other inclinations; to that of honour 19 Morality.

(D) We muft requeft the reader to obferve that this is the language of our correfpondent. We have fhewn elfewhere, that Berkeley did not deny the reality of fenfations; and we hope to fhew by and bye, that Kant is as much an *idealift* as he was, if this be a fair view of the Critical Philofophy.

(E) We have here again taken the liberty to alter the language of our correfpondent. He makes Kant fay, " It is not this knowledge, but a *belief* of reafon, &c.;" but this is furely not the author's meaning. From the context, it is apparent that Kant means to fay, that we have not, and cannot have, what can be properly called a *knowledge* of the exiftence of God, but only fuch a belief of his exiftence as fupplies the place of this impoffible knowledge.

(F) This is a very abfurd phrafe. We fuppofe Kant's meaning to be, that the principles of him whofe actions and volitions are influenced by the profpect of perfonal happinefs, are the reverfe of the pure principles of morality.

honour (for example), which, whilft it meets with that which is juft and ufeful, is worthy of praife and encouragement, but not of any high degree of efteem. According to Kant, we ought not even to *do good*, either for the pleafure we feel in doing it, or in order to be happy or to render others happy; for any one of thefe additions (perhaps motives) would be *empyric*, and injure the purity of our morals. A reafonable being ought to defire to be exempted from all *inclinations*, and never to do his duty but for his duty's fake.

"We ought to act after the maxims derived *a priori* from the faculty of knowledge, which carry with them the idea of neceffity, and are independent of all experience; after the maxims which, it is to be wifhed, could be erected into GENERAL LAWS for all beings endowed with reafon."

20 Futility of this fyftem

If this be a correct view of the object and the refults of the critical philofophy, and the character of him from whom we received it permits us not to doubt of its being nearly correct, we confefs ourfelves unable to difcover any motive which fhould induce our countrymen, in their refearches after truth, to prefer the dark lantern of Kant to the luminous torch of Bacon. The metaphyfical reader will perceive, that, in this abftract, there is little which is new except the phrafeology; and that what is new is neither unitelligible or untenable.

21 Of which the fundamental principles are not new.

The diftinction between knowledge *a priori* and knowledge *a pofteriori*, is as old as fpeculation itfelf; and the mode in which Kant illuftrates that diftinction differs not from the illuftrations of Ariftotle on the fame fubject. The Stagyrite talked of *general forms*, or *formal caufes*, in the mind, as well as the profeffor at Koenigfberg; and he or his difciples (for we quote from memory) compared them to the form of the ftatue in the rough block of marble. As that form is brought into the view of the fpectator by the chiffel of the ftatuary, fo, faid the peripatetics, are the general *forms* in the mind brought into the view of confcioufnefs by fenfation and experience.

Such was the doctrine of Ariftotle and his difciples, and fuch feems to be the doctrine of Kant and his followers; but it is either a falfe doctrine, or, if it be true, a doctrine foolifhly expreffed. A block of marble is capable of being cut into any form that the ftatuary pleafes; into the form of a man, a horfe, an ox, an afs, a fifh, or a ferpent. Not one of thefe forms therefore can be inherent in it, or effential to it, in oppofition to the reft; and a general form, including all the animals under it, is inconceivable and impoffible. In like manner, the human mind is capable of having the ideas of a circle, a triangle, a fquare, of black, white, red, of four, fweet, bitter, of the odour of a rofe, and the ftench of a dunghill, of proportion, of mufical founds, and of a thoufand other things. None of thefe ideas therefore can be effential to the mind in oppofition to the reft; and every man, who is not an abfolute ftranger to the operations of his own intellect, knows well that he cannot think of a thoufand things at once; or, to ufe the language of philofophers, have in his mind a general idea, comprehending under it a thoufand things fo difcordant as colours and founds, figures, and fmells. If therefore Kant means to affirm, with Plato, that, previous to all experience, there are *actually* in the mind *general forms*, or *general ideas*, to which fenfation, or experience, gives an opportunity of coming into view, he affirms what all men of reflexion know to be falfe. If he means only to affirm, what feems to have been the meaning of Ariftotle, that particular fenfations give occafion to the intellect to form general ideas, he expreffes himfelf indeed very ftrangely; but his doctrine on this fubject differs not effentially from that of Locke and Reid, and many other eminent metaphyficians of modern times. Of abftraction and general ideas we have given our own opinion elfewhere (See METAPHYSICS, *Encycl.* Part I. Chap. iv.), and fhall not here refume the fubject.

22 Improper ufe of terms;

But when Kant fays that his ideas *a priori* are *univerfal* and *neceffary*, and that their converfe is *impoffible*, he feems by the word *idea* to mean what more accurate writers exprefs by the term *propofition*. There are indeed two kinds of propofitions, of which both may be true, though the one kind expreffes neceffary and univerfal truths, and the other fuch truths as are contingent and particular. (See METAPHYSICS, *Encycl.* Part I. Chapter vii.) Propofitions directly contrary to thofe which exprefs particular and contingent truths may be eafily conceived; whilft fuch as are contrary to neceffary and univerfal truths are inconceiveable and impoffible; but we doubt whether *any idea*, in the proper fenfe of the word, has a *contrary* or, as he expreffes it, a *converfe*. *Nothing* is not contrary to *fubftance*, nor *black* contrary to *white*, nor *four* contrary to *fweet*, nor an *inch* contrary to an *ell*. Nothing is the negation of fubftance, and black the negation of white; four is different from fweet, and an inch is lefs than an ell; but between thefe different ideas we perceive no contradiction.

That Kant ufes the term *idea* inftead of *propofition*, or fome word of fimilar import, is farther evident from his inftances of *the houfe on fire*, and the manner in which we learn that any two bodies added to any two other bodies will conftantly make the fum of *four bodies*. If it be his will to ufe the terms *a priori* and *a pofteriori* in the fenfe in which other metaphyficians ufe the terms *neceffary* and *contingent*, we can make no other objection to his diftinction between thefe two propofitions, but that it is expreffed in very improper language. The houfe might certainly be *on fire* or *not* on fire; but twice two bodies *muft* always make the fum of four bodies, and cannot poffibly make any other fum.

The truth of this laft propofition (he fays) we cannot have learned from *experience*, becaufe experience, being always limited, cannot poffibly teach us what is *neceffary* and *univerfal*. But this is egregious trifling. The experience employed here is not limited. A child unqueftionably learns the import of the terms of numeration, as he learns the import of all other terms, by experience. By putting two little balls to two little balls, he learns to call the fum *four* balls. After two or three leffons of this kind with different bodies, his own reflection fuggefts to him, that the fum four has no dependance upon the fhape or confiftence of the bodies, but merely upon the *individuality* of each or their numerical difference; and individuality, or numerical difference, is as compleately exemplified in two bodies of any kind as in two thoufand.

23 With its confequences.

All the truths of pure mathematics (fays Kant) are *a priori*. If he means that they are all *neceffary*, and that the contrary of any one of them is *inconceivable*, he affirms nothing but what is true, and has been known to to all mathematicians theſe two thouſand years. But, if he means that they are *innate* truths, not diſcovered by induction or ideal meaſurement, his meaning is demonſtrably falſe. (See INDUCTION in this *Supplement*.) When he ſays, that it is not *experience* which diſcovers to us that we ſhall always have the ſurface of the pyramid, by multiplying its baſe by the third part of its height, he is right, if by experience he means the actual meaſurement of all poſſible pyramids; but ſurely he cannot mean that the truth of this meaſurement is innate in the mind, for it is in fact not a true but a falſe meaſurement (G). The baſe of a pyramid multiplied by the third part of its height gives, not the ſurface, but the ſolid contents of the pyramid; and he who underſtands the propoſition on which this truth is immediately built, knows perfectly that Euclid proved it by a ſeries of ideal meaſurements of thoſe particulars in which all pyramids neceſſarily agree.

Kant ſeems often to confound ſenſation with experience; and if by experience he means *ſenſation*, when he ſays that *pure knowledge, a priori*, is that which is abſolutely without any mixture of experience, he talks nonſenſe; for the moſt ſpiritual notions which men can form are derived from the operations of the mind on ideas of ſenſation. To the reſt of the paragraph, reſpecting pure knowledge, we have hardly any objection to make. Locke, the great enemy of innate ideas, taught, before Kant was born, that our knowledge depends upon our organization and the faculties of our minds, as much as upon impreſſions made on the ſenſes *ab extra*; that if our organs of ſenſe were different from what they are, the taſte of ſugar might be bitter, and that of wormwood ſweet; and that if we had not memory, and could not modify and arrange our ideas, all progreſs in knowledge would be impoſſible.

24 Groundleſs falſe aſſertions.

When our author talks of *time* and *ſpace* as the two eſſential *forms* of the mind, we are not ſure that we underſtand him. We have ſhewn elſewhere, that a conſcious intelligence may be conceived which has no ideas either of ſpace or of time (ſee METAPHYSICS, *Encycl.* n° 182, &c. and 209, &c.); and he who can affirm, that if extenſion were known to us only by *experience*, it would be poſſible to conceive ſenſible objects *without ſpace*, has never attended to the force of what philoſophers call *the aſſociation of ideas of the mind*. But what is here meant by ſenſible objects? Are they objects of touch, taſte, or ſmell? Objects of touch cannot indeed be conceived without ſpace; but what extent of ſpace is ſuggeſted by the taſte of ſugar or the odour of a roſe?

When Kant talks of the *form* ſpace enabling us to attribute to external objects *impenetrability*, *mobility*, &c. he talks at random; and another man may, with as much propriety, and perhaps more truth, affirm the converſe of his propoſitions, and ſay, that it is the impenetrability and mobility, &c. of external objects that enable us to form the idea called *ſpace*, and the ſucceſſion of ſome objects, compared with the permanence of others, that enables us to form the notion or mode called *time*.

On the two or three next paragraphs it is not worth while to detain the reader with many remarks. They abound with the ſame uncouth and obſcure phraſeology, and the ſame idle diſtinctions between ideas *a priori* and *a poſteriori*. In n° 11. he affirms, that the three 25
following propoſitions (*a body is heavy*, *wood is combuſtible*, and *the three angles of a triangle are equal to two right angles*) are all neceſſary judgments. In one ſenſe this affirmation is true, and in another it is falſe. We cannot, without ſpeaking unintelligibly, give the name *body* to any ſubſtance which is not heavy; and we are not acquainted with any kind of *wood* which is not combuſtible; but ſurely it is not impoſſible to conceive a ſubſtance extended and diviſible, and yet *not* heavy, to which the name *body* might be given without abſurdity, or to conceive wood as incombuſtible as the mineral called *aſbeſtos*. That the three angles, however, of a plane triangle can be either more or leſs than equal to two right angles, is obviouſly impoſſible, and muſt be perceived to be ſo by every intelligence from the Supreme down to the human. The three propoſitions, therefore, are not of the ſame kind, and ſhould not have been claſſed under the ſame genus of *neceſſary* ſynthetic judgments.

Bad logic.

In the critique of pure reaſon, Kant ſeems to teach that all demonſtrative ſcience muſt proceed from general principles to particular truths. Hence his *forms* of the underſtanding, and his *categories*, which, according to one of his pupils*, "lie in our underſtanding as pure notions *a priori*, or the foundation of all our knowledge. They are *neceſſary forms*, *radical* notions, of which all our knowledge *muſt* be compounded." But this is directly contrary to the progreſs of the human mind, which, as we have ſhewn in the article INDUCTION, already referred to, proceeds, in the acquiſition of every kind of knowledge, from particular truths to general principles. This *tranſcendental philoſophy* of Kant's, therefore, inverts the order of nature, and is as little calculated to promote the progreſs of ſcience as the ſyllogiſtic ſyſtem of Ariſtotle, which was likewiſe built on *categories* or *general forms*. His *tranſcendental æſthetic*, which, according to Dr Willich, is the knowledge *a priori* of the *rules of ſenſation*, ſeems to be a contradictory expreſſion, as it implies that a man may know the laws of ſenſation, without paying the ſmalleſt attention to the organs of ſenſe.

* *Dr Willich.*

That we know objects only by the manner in which they affect us, and not as they are in themſelves, is a truth admitted, we believe, by all philoſophers, and certainly by Locke and Reid; but when Kant ſays that we know nothing of the *reality* of the objects which affect our ſenſes, he ſeems to be ſingularly paradoxical. Berkeley himſelf, the moſt ingenious idealiſt perhaps that ever wrote, contends ſtrenuouſly for the exiſtence of a *cauſe* of our ſenſations diſtinct from our own minds; and becauſe he thinks inert matter a cauſe inadequate

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(G) This may look like cavalling, as the blunder may be either Kant's or our correſpondent's, though neither of them can be ſuppoſed ignorant of the method of meaſuring the ſurface of a pyramid. We aſſure the reader, however, that we do not mean to cavil. We admit that both Kant and our correſpondent know perfectly well how to meaſure the ſurface of a pyramid; but had that knowledge been *innate* in their minds, we cannot conceive the poſſibility of their falling into the blunder. The blunder, therefore, though the offspring of mere inadvertence, ſeems to be a complete confutation of the doctrine.

inadequate to this effect, he concludes, that every ſenſation of which we are conſcious is a proof of the immediate agency of the Deity. But Kant, as we ſhall perceive by and bye, makes the exiſtence of God and of matter equally problematical. Indeed he ſays expreſsly, that beyond things ſenſible we can only have *opinions* or *belief*; but things ſenſible, as every one knows, are nothing more than the *qualities* of objects.

26 Tendency of the ſyſtem towards atheiſm.

It ſhould ſeem that the greater number of wonders which Kant has found in our primitive knowledge and in the faculties of our mind, the greater number of proofs ought he to have found of the exiſtence and attributes of one Firſt Cauſe; but ſo far is this from being the caſe, that we have ſeen him reſting the evidence of this moſt important of all truths, either upon the *moral ſenſe*, which our paſſions and appetites ſo eaſily alter, or upon the intuitive perception of *abſtract moral rectitude*; a perception which thouſands, as virtuous and as profound as he, have conſidered as impoſſible. Our philoſopher's proof of a God is nothing more than his perſuaſion that happineſs is connected with virtue by a being upon whom nature depends; and he ſays expreſsly, that this proof carries conviction to the mind in proportion as the motives of a man's actions are conformable to the law of morality. This being the caſe, the reader cannot be much ſurpriſed, when he is informed that ſeveral of Kant's diſciples on the continent have avowed themſelves Atheiſts or Spinoziſts. We have elſewhere (ſee ILLUMINATI, n° 37.) mentioned one of thoſe gentlemen who was lately diſmiſſed from his profeſſorial chair in the univerſity of Jena, for making GOD nothing more than an *abſtract idea*, derived from our relations with the moral world. His ſucceſſor, a Kantiſt likewiſe, when it was told in his preſence, that, during one of the maſſacres in Paris, David the Painter ſat with his pencil in his hand, enjoying the ſufferings of the unfortunate wretches, and trying to paint the expreſſions of their agonies, exclaimed—"What force of character! What ſublimity of ſoul!" That this wretch muſt be an Atheiſt, likewiſe, follows of courſe from Kant's principles; for it is not conceivable that he perceives any connection between happineſs and virtue.

That Kant is an atheiſt himſelf, we have not learned, though his doctrine leads thus naturally to atheiſm, and though in his work called TUGEND LEHRE, page 180, he makes the following ſtrange obſervation upon oaths: "As it would be abſurd to ſwear that God exiſts, it is ſtill a queſtion to be determined, whether an oath would be poſſible and obligatory if one were to make it thus—*I ſwear on the ſuppoſition that God exiſts*. It is extremely probable (ſays he), that all *ſincere* oaths, taken with *reflection*, have been taken in no other ſenſe!"

It is not our intention to plunge deeper into this mire of atheiſm, or to enter into a formal confutation of the deteſtable doctrines which have been dragged from its bottom. Enough has been ſaid elſewhere to convince the *theoretical* reaſon of the ſound minds of our countrymen of the exiſtence of one omnipotent, infinitely wiſe, and perfectly good Being, the author and upholder of all things (See *Encycl.* METAPHYSICS, Part III. Chap. vi. and THEOLOGY, Part I. Sect. 1.) It may not, however, be altogether uſeleſs to point out to the reader how completely Kant confutes himſelf, even in the ſhort abſtract that we have given of his ſyſtem.

27 Kant confutes himſelf.

Among his *categories*, or fundamental ideas, which are *neceſſarily* formed in the mind, he expreſsly reckons *cauſe* and *effect*: but in various articles of this work, it has been proved beyond the poſſibility of contradiction, that no *ſenſible* object is the *true metaphyſical cauſe* of any one event in nature; and indeed Kant himſelf is at much pains to ſhew that his *categories* or ideas *a priori* are not ideas of ſenſation. There muſt therefore, upon his own principles, be cauſes which are *not* the objects of *ſenſe* or *experience*; and by tracing theſe cauſes backward, if there be a ſucceſſion of them, we muſt arrive at one ſelf-exiſtent cauſe, by a demonſtration as complete as that by which Euclid proves the equality of the three angles of a plane triangle to two right angles. We have no other evidence for the truth of geometrical axioms than the laws of human thought, which compel us to perceive the impoſſibility of ſuch propoſitions being falſe. According to our philoſopher, we have the very ſame evidence for the reality of cauſes and effects which are not the objects of ſenſe. The conſequence is obvious.

28 His morality is extravagant.

Kant's *political* opinions are ſaid to be tolerably moderate, though he betrays, what we muſt think, an abſurd confidence in the *unlimited perfectibility* of the human mind. On his morality our valued correſpondent has beſtowed a much larger ſhare of his approbation than we can allow it of ours. Kant ſeems to contend, that the actions of men ſhould be directed to no end whatever; for he expreſsly condemns, as an end of action, the purſuit either of our own happineſs or of the happineſs of others, whether temporal or eternal; but actions performed for no purpoſe are ſurely indications of the very eſſence of folly. Such actions are indeed impoſſible to beings endued with reaſon, paſſions, and appetites; for if there be that beauty in abſtract virtue, for which Kant and the Stoics contend, it cannot be but that the virtuous man muſt feel an internal pleaſure when he performs a virtuous action, or reflects upon his paſt conduct. He who makes his temporal intereſt the ſole rule of his conduct, has indeed no pretenſions to the character of a virtuous man; but as the morality of the goſpel has always appeared to us ſufficiently pure and diſintereſted, we think a man may, without deviating into vice, have reſpect unto "the recompence of future reward."

P H O

Phoſphorus.

PHOSPHORUS (See CHEMISTRY *Index*, *Supplement*,) has lately been employed as a medicine by Alphonſus Leroi, profeſſor at the Medical School of Paris. Its effects, in a variety of caſes, are thus deſcribed in the *Bulletin de la Societé Philomatique*, 1798.

1. Phoſphorus adminiſtered internally in conſumptive diſeaſes appears to give a certain degree of activity to life, and to revive the patients, without raiſing their pulſe in the ſame proportion. The author relates ſeveral inſtances that occurred to him in the courſe of his practice;

practice; one of which is as follows: Being called to attend a woman, at the point of death, who was quite worn out by a confumptive diforder, with which fhe had been afflicted for three years, in compliance with the earneft defire of her hufband, who requefted him to give her fome medicine, he compofed one of a portion of fyrup diluted with water, in which a few fticks of phofphorus had been kept. Next day the woman found herfelf much better. She was revived for a few days; and did not die till about a fortnight after.

2. He himfelf, as he acknowledges, was fo imprudent as to take two or three grains of folid phofphorus combined only with treacle, and experienced the moft dreadful fymptoms. At firft he felt a burning heat in the whole region of the ftomach. That organ feemed to be filled with gas which efcaped by the mouth. Being dreadfully tormented, he tried to vomit, but in vain; and found relief only by drinking cold water from time to time. His uneafy fenfations were at length allayed: but next morning he feemed to be endowed with an aftonifhing mufcular force, and to be urged, with an almoft irrefiftible impulfe to try its energy. The effect of this medicine at length ceafed, adds the author, *à la fuite d'un priapifme violent*.

3. In many cafes the author employed, and ftill employs, phofphorus internally, with great benefit, to reftore and revive young perfons exhaufted by exceffes. He divides the phofphorus into very fmall particles, by fhaking it in a glafs filled with boiling water. He continues to fhake the bottle, plunging it into cold water, and thus obtains a kind of precipitate of phofphorus, exceedingly fine, which he bruifes flowly with a little oil and fugar, or afterwards employs as liquid electuary, by diluting the whole in the yoke of an egg. By means of this medicine he has effected aftonifhing cures, and reftored the ftrength of his patients in a very fhort time.

4. In malignant fevers the ufe of phofphorus internally, to check the progrefs of gangrene, has fucceeded beyond expectation. The author relates feveral inftances.

5. Pelletier told him, that having left, through negligence, fome phofphorus in a copper bafon, that metal was oxidated, and remained fufpended in the water. Having thoughtlefsly thrown out the water in a fmall court in which ducks were kept, thefe animals drank of it, and all died. *Mais le male* (fays the author) *couvrit toutes fes femelles jufque au dernier inftant de fa vie*. An obfervation which accords with the effect experienced by the author.

6. The author relates a fact which proves the aftonifhing divifibility of phofphorus. Having adminiftered to a patient fome pills, in the compofition of which there was not more than a quarter of a grain of phofphorus, and having had occafion afterwards to open the body, he found all the internal parts luminous; and even the hands of the perfon who had performed the operation, though wafhed and well dried, retained a phofphoric fplendor for a long time after.

7. The phofphoric acid, employed as lemonade, has been ferviceable to the author in the cure of a great number of difeafes.

8. Leroi affures us that he oxidated iron with phofphorus, and obtained, by the common means, a white oxide, almoft irreducible, which he thinks may be employed with advantage in the arts, and particularly in painting with oil, and in enamel, inftead of the white oxide of lead. This white oxide of iron occafioned violent retchings to the author, who ventured to place a very fmall particle of it on his tongue. He does not hefitate, therefore, to confider this oxide as a terrible poifon. He was not able to reduce it but by fixed alkali and the glafs of phofphorus.

9. The author afferts that, by means of phofphorus, he decompofed and feparated from their bafes the fulphuric, muriatic, and nitric acids; that by help of the phofphoric acid he tranfmuted earths; and that with calcareous earth he can make, at pleafure, confiderable quantities of magnefia. He declares, that to his labours on phofphorus he is indebted for proceffes by which he effects the diffipation (*opere la frite*) of rubies, the fufion of emeralds, and the vitrification of mercury.

We agree with the editor of the refpectable Mifcellany *, from which we have immediately taken this article, that Britifh practitioners will do well to ufe their wonted caution in the application of fo powerful a remedy. Indeed we confider it as fo very *hazardous* a remedy, that we had refolved to make no mention of it, till we found it tranfcribed into various journals, both foreign and domeftic, and thence began to fufpect that we might be accufed of culpable negligence, were we to pafs unnoticed what had attracted the attention of fo many of our fellow-labourers in the field of fcience.

* *Philofophical Magazine*, vol. ii.

PHOSPHORUS, in aftronomy, is the morning ftar, or the planet Venus, when fhe rifes before the fun. The Latins call it *Lucifer*, the French *Etoile de berger*, and the Greeks *Phofphorus*.

PHOTOMETER, an apparatus for meafuring the intenfity of light, and likewife the tranfparency of the medium through which it paffes. Inftruments for this purpofe have been invented by Count Rumford, M. de Sauffure, that eminent mathematician and philofopher Mr John Leflie, and others. We fhall content ourfelves with defcribing in this place the photometer of Count Rumford, and the inftrument to which Sauffure gives the name of *diaphanometer*. Mr Leflie's is indeed the fimpleft inftrument of the kind of which we have anywhere met with a defcription; but it meafures only the momentary intenfities of light; and he who wifhes to be informed of its conftruction, will find that information in the third volume of Nicholfon's Philofophical Journal.

Count Rumford, when making the experiments which we have noticed in the article LAMP (*Suppl.*), was led, ftep by ftep, to the conftruction of a very accurate *photometer*, in which the fhadows, inftead of being thrown upon a paper fpread out upon the wainfcot, or fide of the room (See page 64 of this volume), are projected upon the infide of the back part of a wooden box $7\frac{1}{2}$ inches wide, $10\frac{1}{4}$ inches long, and $3\frac{1}{4}$ inches deep, in the clear. The light is admitted into it through two horizontal tubes in the front, placed fo as to form an angle of 60°; their axes meeting at the centre of the field of the inftrument. In the middle of the front of the box, between thefe two tubes, is an opening thro' which is viewed the field of the photometer (See fig. 1.). This field is formed of a piece of white paper, which is not faftened immediately upon the infide of the back of the box, but is pafted upon a fmall pane of very fine ground glafs; and this glafs, thus covered, is

Plate XLI.

Photometer.

is let down into a groove, made to recive it, in the back of the box. The whole inside of the box, except the field of the instrument, is painted of a deep black dead colour. To the under parts of the box is fitted a ball and socket, by which it is attached to a stand which supports it; and the top or lid of it is fitted with hinges, in order that the box may be laid quite open, as often as it is necessary to alter any part of the machinery it contains.

The Count had found it very inconvenient to compare two shadows projected by the same cylinder, as these were either necessarily too far from each other to be compared with certainty, or, when they were nearer, were in part hid from the eye by the cylinder. To remedy this inconvenience, he now makes use of two cylinders, which are placed perpendicularly in the bottom of the box just described, in a line parallel to the back part of it, distant from this back $2\frac{2}{10}$ inches, and from each other 3 inches, measuring from the centres of the cylinders; when the two lights made use of in the experiment are properly placed, these two cylinders project four shadows upon the white paper upon the inside of the back part of the box, or the *field* of the instrument; two of which shadows are in contact, precisely in the middle of that field, and it is these two alone that are to be attended to To prevent the attention being distracted by the presence of unnecessary objects, the two outside shadows are made to disappear; which is done by rendering the field of the instrument so narrow, that they fall without it, upon a blackened surface, upon which they are not visible. If the cylinders be each $\frac{4}{10}$ of an inch in diameter, and $2\frac{2}{10}$ inches in height, it will be quite sufficient that the field be $2\frac{7}{10}$ inches wide; and as an unnecessary height of the field is not only usefess, but disadvantageous, as a large surface of white paper not covered by the shadows produces too strong a glare of light, the field ought not to be more than $\frac{3}{10}$ of an inch higher than the tops of the cylinders. That its dimensions, however, may be occasionally augmented, the covered glass should be made $5\frac{1}{2}$ inches long, and as wide as the box is deep, viz. $3\frac{3}{4}$ inches; since the field of the instrument can be reduced to its proper size by a screen of black pasteboard, interposed before the anterior surface of this covered glass, and resting immediately upon it. A hole in this pasteboard, in the form of an oblong square, $1\frac{7}{10}$ inch wide, and two inches high, determines the dimensions, and forms the boundaries of the field. This screen should be large enough to cover the whole inside of the back of the box, and it may be fixed in its place by means of grooves in the sides of the box, into which it may be made to enter. The position of the opening above mentioned is determined by the height of the cylinders; the top of it being $\frac{1}{10}$ of an inch higher than the tops of the cylinders; and as the height of it is only two inches, while the height of the cylinders is $2\frac{2}{10}$ inches, it is evident that the shadows of the lower parts of the cylinders do not enter the field. No inconvenience arises from that circumstance; on the contrary, several advantages are derived from that arrangement.

That the lights may be placed with facility and precision, a fine black line is drawn through the middle of the field, from the top to the bottom of it, and another (horizontal) line at right angles to it, at the height of the top of the cylinders. When the tops of the shadows touch this last-mentioned line, the lights are at a proper height: and farther, when the two shadows are in contact with each other in the middle of the field, the lights are then in their proper directions.

We have said that the cylinders, by which the shadows are projected, are placed perpendicularly in the bottom of the box; but as the diameters of the shadows of these cylinders vary in some degree, in proportion as the lights are broader or narrower, and as they are brought nearer to or removed farther from the photometer, in order to be able in all cases to bring these shadows to be of the same diameter, which is very advantageous, in order to judge with greater facility and certainty when they are of the same density, the Count renders the cylinders moveable about their axes, and adds to each a vertical wing $\frac{1}{10}$ of an inch wide, $\frac{1}{10}$ of an inch thick, and of equal height with the cylinder itself, and firmly fixed to it from the top to the bottom. This wing commonly lies in the middle of the shadow of the cylinder, and as long as it remains in that situation it has no effect whatever; but when it is necessary that the diameter of one of the shadows be increased, the corresponding cylinder is moved about its axis, till the wing just described, emerging out of the shadow, and intercepting a portion of light, brings the shadow projected upon the field of the instrument to be of the width or diameter required. In this operation it is always necessary to turn the cylinder outwards, or in such a manner that the augmentation of the width of the shadow may take place on that side of it which is opposite to the shadow corresponding to the other light. The necessity for that precaution will appear evident to any one who has a just idea of the instrument in question, and of the manner of making use of it. They are turned likewise without opening the box, by taking hold of the ends of their axes, which project below its bottom.

As it is absolutely necessary that the cylinders should constantly remain precisely perpendicular to the bottom of the box, or parallel to each other, it will be best to construct them of brass; and, instead of fixing them immediately to the bottom of the box (which, being of wood, may warp), to fix them to a strong thick piece of well-hammered plate brass; which plate of brass may be afterwards fastened to the bottom of the box by means of one strong screw. In this manner two of the Count's best instruments are constructed; and, in order to secure the cylinders still more firmly in their vertical positions, they are furnished with broad flat rings, or projections, where they rest upon the brass plate; which rings are $\frac{1}{10}$ of an inch thick, and equal in diameter to the projection of the wing of the cylinder, to the bottom of which they afford a firm support. These cylinders are likewise forcibly pushed, or rather pulled, against the brass plate upon which they rest, by means of compressed spiral springs placed between the under side of that plate and the lower ends of the cylinders. Of whatever material the cylinders be constructed, and whatever be their forms or dimensions, it is absolutely necessary that they, as well as every other part of the photometer, except the field, should be well painted of a deep black dead colour.

In order to move the lights to and from the photometer with greater ease and precision, the observer should provide two long and narrow, but very strong and steady, tables; in the middle of each of which there

there is a ſtraight groove, in which a ſliding carriage, upon which the light is placed, is drawn along by means of a cord which is faſtened to it before and behind, and which, paſſing over pulleys at each end of the table, goes round a cylinder; which cylinder is furniſhed with a winch, and is ſo placed, near the end of the table adjoining the photometer, that the obſerver can turn it about, without taking his eye from the field of the inſtrument.

Many advantages are derived from this arrangement: Firſt, the obſerver can move the lights as he finds neceſſary, without the help of an aſſiſtant, and even without removing his eye from the ſhadows; ſecondly, each light is always preciſely in the line of direction in which it ought to be, in order that the ſhadows may be in contact in the middle of the vertical plane of the photometer; and, thirdly, the ſliding motion of the lights being perfectly ſoft and gentle, that motion produces little or no effect upon the lights themſelves, either to increaſe or diminiſh their brilliancy.

Theſe tables muſt be placed at an angle of 60 degrees from each other, and in ſuch a ſituation, with reſpect to the photometer, that lines drawn through their middles, in the direction of their lengths, meet in a point exactly under the middle of the vertical plane or field of the photometer, and from that point the diſtances of the lights are meaſured; the ſides of the tables being divided into Engliſh inches, and a vernier, ſhewing tenths of inches, being fixed to each of the ſliding carriages upon which the lights are placed, and which are ſo contrived that they may be raiſed or lowered at pleaſure; ſo that the lights may be always in a horizontal line with the tops of the cylinders of the photometer.

In order that the two long and narrow tables or platforms, juſt deſcribed, may remain immoveable in their proper poſitions, they are both firmly fixed to the ſtand which ſupports the photometer; and in order that the motion of the carriages which carry the lights may be as ſoft and gentle as poſſible, they are made to ſlide upon parallel braſs wires, 9 inches aſunder, about $\frac{1}{10}$ of an inch in diameter, and well poliſhed, which are ſtretched out upon the tables from one end to the other.

The ſtructure of the apparatus will be clearly underſtood by a bare inſpection of Plate XLI. where fig. 1. is a plan of the inſide of the box, and the adjoining parts of the photometer. Fig. 2. Plan of the two tables belonging to the photometer. Fig. 3. The box of the photometer on its ſtand. Fig. 4. Elevation of the photometer, with one of the tables and carriages.

Having ſufficiently explained all the eſſential parts of this photometer, it remains for us to give ſome account of the precautions neceſſary to be obſerved in uſing it. And, firſt, with reſpect to the diſtance at which lights, whoſe intenſities are to be compared, ſhould be placed from the field of the inſtrument, the ingenious and accurate inventor found, that when the weakeſt of the lights in queſtion is about as ſtrong as a common wax-candle, that light may moſt advantageouſly be placed from 30 to 36 inches from the centre of the field; and when it is weaker or ſtronger, proportionally nearer or farther off. When the lights are too near, the ſhadows will not be well defined; and when they are too far off, they will be too weak.

It will greatly facilitate the calculations neceſſary in drawing concluſions from experiments of this kind, if ſome ſteady light, of a proper degree of ſtrength for that purpoſe, be aſſumed as a ſtandard by which all others may be compared. Our author found a good Argand's lamp much preferable for this purpoſe to any other lamp or candle whatever. As it appears, he ſays, from a number of experiments, that the quantity of light emitted by a lamp, which burns in the ſame manner with a clear flame, and *without ſmoke*, is in all caſes as the quantity of oil conſumed, there is much reaſon to ſuppoſe, that, if the Argand's lamp be ſo adjuſted as always to conſume a given quantity of oil in a given time, it may then be depended on as a juſt ſtandard of light.

In order to abridge the calculations neceſſary in theſe inquiries, it will always be advantageous to place the ſtandard-lamp at the diſtance of 100 inches from the photometer, and to aſſume the intenſity of its light at its ſource equal to unity; in this caſe (calling this ſtandard light A, the intenſity of the light at its ſource $= x = 1$, and the diſtance of the lamp from the field of the photometer $= m = 100$), the intenſity of the illumination at the field of the photometer $(= \frac{x}{m^2})$ (See Lamp, p. 67. of this volume) will be expreſſed by the fraction $\frac{1}{100^2} = \frac{1}{10000}$; and the relative intenſity of any other light which is compared with it, may be found by the following proportion: Calling this light B, putting $y =$ its intenſity at its ſource, and $n =$ its diſtance from the field of the photometer, expreſſed in Engliſh inches, as it is $\frac{y}{n^2} = \frac{x}{m^2}$, as was ſhewn in the article Lamp referred to; or, inſtead of $\frac{x}{m^2}$, writing its value $= \frac{1}{10000}$, it will be $\frac{y}{n^2} = \frac{1}{10000}$; and conſequently y is to 1 as n^2 is to 10000; or the intenſity of the light B at its ſource, is to the intenſity of the ſtandard light A at its ſource, as the ſquare of the diſtance of the light B from the middle of the field of the inſtrument, expreſſed in inches, is to 10000; and hence it is $y = \frac{n^2}{10000}$.

Or, if the light of the ſun, or that of the moon, be compared with the light of a given lamp or candle C, the reſult of ſuch compariſon may beſt be expreſſed in words, by ſaying, that the light of the celeſtial luminary in queſtion, *at the ſurface of the earth*, or, which is the ſame thing, at the field of the photometer, is equal to the light of the given lamp or candle, *at the diſtance found by the experiment*; or, putting $a =$ the intenſity of the light of this lamp C at its ſource, and $p =$ its diſtance, in inches, from the field, when the ſhadows correſponding to this light, and that correſponding to the celeſtial luminary in queſtion, are found to be of equal denſities, and putting $z =$ the intenſity of the rays of the luminary at the ſurface of the earth, the reſult of the experiment may be expreſſed thus, $z = \frac{a}{p^2}$; or the real value of a being determined by a particular experiment, made expreſly for that purpoſe with the ſtandard-lamp, that value may be written inſtead of it. When the ſtandard-lamp itſelf is made uſe of, inſtead of the lamp C, then the value of A will be 1.

The Count's firſt attempts with his photometer were to determine how far it might be poſſible to aſcertain, by by direct experiments, the certainty of the affumed law of the diminution of the intenfity of the light emitted by luminous bodies ; namely, that the intenfity of the light is everywhere as the fquares of the diftances from the luminous body inverfely. As it is obvious that this law can hold good only when the light is propagated through perfectly tranfparent fpaces, fo that its intenfity is weakened merely by the divergency of its rays, he inftituted a fet of experiments to afcertain the tranfparency of the air and other mediums.

With this view, two equal wax candles, well trimmed, and which were found, by a previous experiment, to burn with exactly the fame degree of brightnefs, were placed *together*, on one fide, before the photometer, and their united light was counterbalanced by the light of an Argand's lamp, well trimmed, and burning very equally, placed on the other fide over againft them. The lamp was placed at the diftance of 100 inches from the field of the photometer, and it was found that the two burning candles (which were placed as near together as poffible, without their flames affecting each other by the currents of air they produced) were juft able to counterbalance the light of the lamp at the field of the photometer, when they were placed at the diftance of 60,8 inches from that field. One of the candles being now taken away and extinguifhed, the other was brought nearer to the field of the inftrument, till its light was found to be juft able, fingly, to counterbalance the light of the lamp; and this was found to happen when it had arrived at the diftance of 43,4 inches. In this experiment, as the candles burnt with equal brightnefs, it is evident that the intenfities of their united and fingle lights were as 2 to 1, and in that proportion ought, according to the affumed theory, the fquares of the diftances, 60,8 and 43,4 to be; and, in fact, $\overline{60,8}^2 = 3696,64$ is to $\overline{43,4}^2 = 1883,56$ as 2 is to 1 very nearly.

Again, in another experiment, the diftances were,

With two candles = 54 inches.	Square	= 2916
With one candle = 38,6	- -	= 1489,96

Upon another trial,

With two candles = 54,6 inches.	Square	= 2981,16
With one candle = 39,7	- -	= 1576,09

And, in the fourth experiment,

With two candles = 58,4 inches.	Square	= 3410,56
With one candle = 42,2	- -	= 1780,84

And, taking the mean of the refults of thefe four experiments,

	Squares of the Diftances With two Candles.		With one Candle.
In the Experiment N° 1.	3696,64	—	1883,56
N° 2.	2916	—	1489,96
N° 3.	2981,16	—	1576,09
N° 4.	3410,56	—	1780,84
	4) 13004,36		4) 6730,45
Means	3251,09	and	1682,61

which again are very nearly as 2 to 1.

With regard to thefe experiments, it may be obferved, that were the refiftance of the air to light, or the diminution of the light from the imperfect tranfparency of air, fenfible within the limits of the inconfiderable diftances at which the candles were placed from the photometer, in that cafe the diftance of the two equal lights united ought to be, to the diftance of one of them fingle in a ratio lefs than that of the fquare root of 2 to the fquare root of 1. For if the intenfity of a light emitted by a luminous body, *in a fpace void of all refiftance*, be diminifhed in the proportion of the fquares of the diftances, it muft of neceffity be diminifhed in a ftill higher ratio when the light paffes thro' a refifting medium, or one which is not perfectly tranfparent ; and from the difference of thofe ratios, namely, that of the fquares of the diftances, and that other higher ratio found by the experiment, the refiftance of the medium might be afcertained. This he took much pains to do with refpect to air, but did not fucceed ; the tranfparency of air being fo great, that the diminution which light fuffers in paffing through a few inches, or even through feveral feet of it, is not fenfible.

Having found, upon repeated trials, that the light of a lamp, properly trimmed, is incomparably more equal than that of a candle, whofe wick, continually growing longer, renders its light extremely fluctuating, he fubftituted lamps to candles in thefe experiments, and made fuch other variations in the manner of conducting them as he thought bid fair to lead to a difcovery of the refiftance of the air to light, were it poffible to render that refiftance fenfible within the confined limits of his machinery. But the refults of them, fo far from affording means for afcertaining the refiftance of the air to light, do not even indicate any refiftance at all ; on the contrary, it might almoft be inferred, from fome of them, that the intenfity of the light emitted by a luminous body in air is diminifhed in a ratio *lefs* than that of the fquares of the diftances ; but as fuch a conclufion would involve an evident abfurdity, namely, that light moving in air, its abfolute quantity, inftead of being diminifhed, actually goes on to *increafe*, that conclufion can by no means be admitted.

Why not ? Theories muft give place to facts ; and if this fact can be fairly afcertained, inftead of rejecting the conclufion, we ought certainly to rectify our notions of light, the nature of which we believe no man fully comprehends. Who can take it upon him to fay, that the fubftance of light is not latent in the atmofphere, as heat or caloric is now acknowledged to be latent, and that the agency of the former is not called forth by the paffage of a ray through a portion of air, as the agency of the latter is known to be excited by the combination of oxygen with any combuftible fubftance? See CHEMISTRY, n° 293, *Suppl.*

The ingenious author's experiments all confpired to fhew that the refiftance of the air to light is too inconfiderable to be perceptible, and that the affumed law of the diminution of the intenfity of light may be depended upon with fafety. He admits, however, that means may be found for rendering the air's refiftance to light apparent ; and he feems to have thought of the very means which occurred for this purpofe to M. de Sauffure.

That eminent philofopher, wifhing to afcertain the tranfparency of the atmofphere, by meafuring the diftances at which determined objects ceafe to be vifible, perceived at once that his end would be attained, if he fhould find objects of which the difappearance might be accurately determined. Accordingly, after many trials, he found that the moment of difappearance can be obferved with much greater accuracy when a black object

object is placed on a white ground, than when a white object is placed on a black ground; that the accuracy was still greater when the observation was made in the sun than in the shade; and that even a still greater degree of accuracy was obtained, when the white space surrounding a black circle, was itself furrounded by a circle or ground of a dark colour. This last circumstance was particularly remarkable, and an observation quite new.

If a circle totally black, of about two lines in diameter, be fastened on the middle of a large sheet of paper or pasteboard, and if this paper or pasteboard be placed in such a manner as to be exposed fully to the light of the sun, if you then approach it at the distance of three or four feet, and afterwards gradually recede from it, keeping your eye constantly directed towards the black circle, it will appear always to decrease in size the farther you retire from it, and at the distance of 33 or 34 feet will have the appearance of a point. If you continue still to recede, you will see it again enlarge itself; and it will seem to form a kind of cloud, the darkness of which decreases more and more according as the circumference becomes enlarged. The cloud will appear still to increase in size the farther you remove from it; but at length it will totally disappear. The moment of the disappearance, however, cannot be accurately ascertained; and the more experiments were repeated the more were the results different.

M. de Saussure, having reflected for a long time on the means of remedying this inconveniency, saw clearly, that, as long as this cloud took place, no accuracy could be obtained; and he discovered that it appeared in consequence of the contrast formed by the white parts which were at the greatest distance from the black circle. He thence concluded, that if the ground was left white near this circle, and the parts of the pasteboard at the greatest distance from it were covered with a dark colour, the cloud would no longer be visible, or at least almost totally disappear.

This conjecture was confirmed by experiment. M. de Saussure left a white space around the black circle equal in breadth to its diameter, by placing a circle of black paper a line in diameter on the middle of a white circle three lines in diameter, so that the black circle was only surrounded by a white ring a line in breadth. The whole was pasted upon a green ground. A green colour was chosen, because it was dark enough to make the cloud disappear, and the easiest to be procured.

The black circle, surrounded in this manner with white on a green ground, disappeared at a much less distance than when it was on a white ground of a large size.

If a perfectly black circle, a line in diameter, be pasted on the middle of a white ground exposed to the open light, it may be observed at the distance of from 44 to 45 feet; but if this circle be surrounded by a white ring a line in breadth, while the rest of the ground is green, all sight of it is lost at the distance of only $15\frac{1}{2}$ feet.

According to these principles, M. de Saussure delineated several black circles, the diameters of which increased in a geometrical progression, the exponent of which was $\frac{3}{2}$. His smallest circle was $\frac{1}{5}$ or 0·2 of a line in diameter; the second 0·3; the third 0·45; and so on to the sixteenth, which was 87·527, or about 7 inches $3\frac{1}{2}$ lines. Each of these circles was surrounded by a white ring, the breadth of which was equal to the diameter of the circle, and the whole was pasted on a green ground.

M. de Saussure, for his experiments, selected a straight road or plain of about 1200 or 1500 feet in circumference, which towards the north was bounded by trees or an ascent. Those who repeat them, however, must pay attention to the following remarks: When a person retires backwards, keeping his eye constantly fixed on the pasteboard, the eye becomes fatigued, and soon ceases to perceive the circle; as soon therefore as it ceases to be distinguishable, you must suffer your eyes to rest; not, however, by shutting them, for they would when again opened be dazzled by the light, but by turning them gradually to some less illuminated object in the horizon. When you have done this for about half a minute, and again directed your eyes to the pasteboard, the circle will be again visible, and you must continue to recede till it disappear once more. You must then let your eyes rest a second time in order to look at the circle again, and continue in this manner till the circle becomes actually invisible.

If you wish to find an accurate expression for the want of transparency, you must employ a number of circles, the diameters of which increase according to a certain progression; and a comparison of the distances at which they disappear will give the law according to which the transparency of the atmosphere decreases at different distances. If you wish to compare the transparency of the atmosphere on two days, or in two different places, two circles will be sufficient for the experiment.

According to these principles, M. de Saussure caused to be prepared a piece of white linen cloth eight feet square. In the middle of this square he sewed a perfect circle, two feet in diameter, of beautiful black wool; around this circle he left a white ring two feet in breadth, and the rest of the square was covered with pale green. In the like manner, and of the same materials, he prepared another square; which was, however, equal to only $\frac{1}{12}$ of the size of the former, so that each side of it was 8 inches; the black circle in the middle was two inches in diameter, and the white space around the circle was two inches also.

If two squares of this kind be suspended vertically and parallel to each other, so that they may be both illuminated in an equal degree by the sun; and if the atmosphere, at the moment when the experiment is made, be perfectly transparent, the circle of the large square, which is twelve times the size of the other, must be seen at twelve times the distance. In M. de Saussure's experiments the small circle disappeared at the distance of 314 feet, and the large one at the distance of 3588 feet, whereas it should have disappeared at the distance of 3768. The atmosphere, therefore, was not perfectly transparent. This arose from the thin vapours which at that time were floating in it. M. de Saussure, as we have observed, calls his instrument a *diaphanometer;* but as it answers one of the purposes of a photometer, we trust our readers will not consider this account of it as a digression.

To return to Count Rumford. From a number of experiments made with his *photometer*, he found that, by passing through a pane of fine, clear, well polished glass, such as is commonly made use of in the construction of looking-glasses, light loses ,1973 of its whole

quantity,

quantity, *i. e.* of the quantity which impinged on the glafs; that when light is made to pafs through two panes of fuch glafs ftanding parallel, but not touching each other, the lofs is ,3184 of the whole; and that in paffing through a very thin, clear, colourlefs pane of window-glafs, the lofs is only ,1263. Hence he infers that this apparatus might be very ufefully employed by the optician, to determine the degree of tranfparency of glafs, and direct his choice in the provifion of that important article of his trade. The lofs of light when reflected from the very beft plain glafs mirror, the author afcertained, by five experiments, to be $\frac{1}{3}$d of the whole which fell upon the mirror.

PHYSIOGNOMY is a fcience, if it be entitled to that name, on which we may be thought to have faid enough in the *Encyclopædia.* Since that period we have been favoured with a fhort view of a new fyftem by Dr Gall of Vienna, who calls it the *Craniognomic* fyftem, becaufe he infers the powers and difpofitions of the mind from the *exterior form of the cranium.*

Having obferved that the brain is the material organ of the action of the mind, and that it increafes in direct proportion to the faculties of animals, he endeavours to prove that the faculties are *diftinct* and *independent* on each other; that each has its proper material organ; and that the expanfion of the organ is in proportion to the ftrength of the faculty. This, which is the foundation of his fyftem, looks very like materialifm; and affords one of many proofs that might be brought of the readinefs of the German philofophers to teach fciences which they have never learned. Let us attend, however, to the reafoning by which he endeavours to fupport this foundation.

" The internal faculties do not always exift in the fame proportion to each other. There are fome men who have a great deal of genius without having a memory, who have courage without circumfpection, and who poffefs a metaphyfical fpirit without being good obfervers. Befides, the phenomena of dreaming, of fomnambulifm, of delirium, &c. prove to us that the internal faculties do not always act together; that there is often a very great activity of one, while the reft are not fenfible. Thus in old age, and fometimes in difeafe (fuch, for example, as madnefs), feveral faculties are loft, while others fubfift; befides a continued employment of the fame faculty fenfibly diminifhes its energy: if we employ another, we find it has all the force of which it is fufceptible: and if we return to the former faculty, it is obferved that it has refumed its ufual vigour. It is thus that, when fatigued with reading an abftract philofophical work, we proceed with pleafure to a poetical one, and then refume with the fame attention our former occupation. All thefe phenomena prove, continues our author, that the faculties are diftinct and independent on each other; and we are inclined to believe that the cafe is the fame with their material organs *."

* *Phil. Mag.* vol. xiv. p. 77, &c.

Have Dr Gall and his friend Dr Bojanus, the author of this view, never paid attention to their own confcioufnefs? or do they fuppofe that the teftimony of confcioufnefs is not to be regarded? To us nothing can be more evident than that the fame individual being fees, and hears, and reafons, and remembers, and conceives, fometimes fober truths, and fometimes paradoxical abfurdities. If *they* think otherwife, it would be extremely kind in them to explain the procefs by which the *thirty-two diftinct and independent faculties,* which operate in the cranium of Dr Gall, came to unite in the compofition of this fyftem of fcience; to compare their different operations together; or indeed to know, each, that his one-and-thirty brothers have any exiftence! To us fuch a union in fyftem-building, among diftinct and independent beings, in the fame cranium, appears juft as impoffible as a mutual confcioufnefs among fo many men, diftant, each from the others, a thoufand miles; and it would be as eafy to perfuade us that Dr Gall is privy to the thoughts of the Emperor of China, as that a collection of independent faculties, refiding in his fkull, know what each other is doing.

If we examine the reafoning upon which this abfurd theory is built, nothing will appear lefs conclufive. Granting that there may be a great deal of genius without memory, that there may be courage without circumfpection; a metaphyfical fpirit without a talent for obfervation; and that, in old age and madnefs, feveral faculties may feem to be loft, while others remain in full vigour —may not all this refult from the perfection or imperfection of the material organs in the brain? If one portion of the brain be the organ of genius, and another the organ of memory, and if the former of thefe organs be in a ftate of high perfection when compared with the other--it is obvious that the man, whofe brain is fo conftituted, muft appear to poffefs a great deal of genius with little memory, though his efforts of genius and memory be the efforts of one individual being. A man with his left hand, aided by a lever in the proportion of three to one, will raife a much greater weight than he could raife with his right hand, aided by a lever equally divided; but it would be very ridiculous, from this fact, to infer, that the mufcular ftrength of his left arm is greater than that of his right.

His next principle is, that "*the expanfion of the organs contained in the cranium is in the direct ratio of the force of their correfponding faculties.* This principle (he fays), dictated by analogy, refts on this axiom, that throughout all nature the faculties are always found to be proportioned to their relative organs." This feems to be reafoning in a circle; and it takes for granted what we have proved to be falfe. The mind does not confift of fo many diftinct and independent faculties; and if it did, the affertion which is here ftyled an *axiom* would authorife us only to infer the ftrength of the faculty from the fize of the organ, and by no means the fize of the organ from the ftrength of the faculty.

But how does our author know, that throughout all nature the faculties are always found to be proportioned to their organs? Why, he does *not* know it; for he admits, that " exercife has a great influence on the force of the faculties; and that an organ moderately expanded, but often exercifed, can give a faculty fuperior to that which accompanies a very extenfive organ never put in action." If this be true, there feems to be an end of the fyftem; for its object is to afcertain, from the external appearance of the cranium, the internal powers and difpofitions of the mind. Now, the external appearance or conformation of the cranium depends on that of the brain. " Obfervation (fays the author of the View) has proved to Dr Gall, that we cannot judge of the ftrength of the faculties, but by the

the developement of the *ſeparate organs which form diſtinct eminences in the cranium*; and that a cranium perfectly round, of whatever ſize it may be, is never a proof of many or of great faculties." But if it be true that an organ moderately expanded, but often exerciſed, indicates a faculty ſuperior to that which accompanies a very extenſive organ never put in action, it follows incontrovertibly, that no man, however well acquainted with the organic ſtructure of the brain, can infer with certainty, from the eminences of the cranium, what faculties or diſpoſitions predominate in the mind. Nay it follows, that a cranium perfectly round (if there be ſuch a cranium) may contain many and great faculties; for if the moderately expanded organs be moſt exerciſed, their faculties will acquire ſtrength, while the preſſure on the ſkull is equally balanced on all ſides.

PIANO FORTE, otherwiſe called FORTE PIANO, a well known muſical inſtrument, of which we need make no apology for conſidering the peculiarities with ſome attention. If we look on muſic from no higher point of view than as the *laborum dulce lenimen*, the innocent, the ſoothing, the cheering ſweetener of toil, we muſt acknowledge that it is far from being the meaneſt of thoſe enjoyments with which the Bountiful Father of Men has embelliſhed this ſcene of our exiſtence. But there is a *ſcience* in muſic, independent of that artificial half mathematical doctrine which we have contrived to unite with it, and which really enables us to improve pure muſical pleaſure. Hence in the Engliſh univerſities degrees are conferred in muſic.

The voice is the original muſical inſtrument, and all others are but imitations. The voice of man obeys the impulſe of the heart with wonderful promptitude, and ſtill more wonderful accuracy. A very coarſe ear is hurt by an error in its tone, amounting to what is called a *comma*. A very limited voice can execute melodies extending to 12 notes, or an octave and a fifth. The motion of the glottis between theſe extremes does not amount to $\frac{1}{11}$th of an inch. This muſt therefore be divided, by the moſt ordinary finger, into more than a thouſand parts; and this muſt be done in an inſtant, and repeated with rapidity, without ever miſtaking one of theſe diviſions; and this is done everywhere, and without any ſeeming effort or thought. The mechaniſm of the human organ for effecting this with eaſe and preciſion is very remarkable, and ſeems to prove that the Author of our being meant to give us this pleaſure.

When, in the cultivation of this fruit of our own ſoil, the moderns diſcovered the beauties of harmony or conſonance, and inſtruments of fixed ſounds were employed, by means of which theſe beauties could be exhibited in their utmoſt richneſs and variety; and particularly when the organ, that " magic world of ſound," was invented, the immenſe advantages of the ingenious ſpeculations of the ancient Greeks about the diviſion of the monochord were now perceived, and muſic became a deep intellectual ſtudy. It fell into the hands of men of letters, and, for a long while, counterpoint occupied all their attention. Inſtruments of fixed ſounds were now made, not only with pipes, but with ſtrings, bells, rings, and every thing that could make a noiſe in tune.

But all theſe inſtruments were far inferior to the voice, the ſpontaneous gift of Nature, in promptitude, and in the power of obeying every call of ſentiment, every degree, as well as every kind of emotion, with which the heart was agitated. The pleaſures of harmony, though great, were monotonous, and could not expreſs the momentary variations of ſentiment, which are as fleeting as the light and ſhade of a proſpect while the dappled clouds ſail acroſs the ſky. The violin, and a ſmall number of the ſimple wind inſtruments, were found to be the only ones which could fully expreſs thoſe momentary gradations of ſentiment that give muſic its pathos, and enable it to thrill the very ſoul.

Attempts were made to remove this defect of the harmonic inſtruments, and the SWELL was added to the organ. The effect was great, and encouraged the artiſts to attempt ſimilar improvements on other inſtruments of the ſame kind. This was firſt done in the ſame way as in the organ. The harpſichord was ſhut up, like the ſwell organ, and was opened by means of pedals when the performer wiſhed to enforce the ſound. But the effect was far inferior to that of the ſwell organ; for this was (at leaſt in all great organs) a real addition of another properly ſelected ſound. But the effect of the pedal on the harpſichord could not be miſtaken; it was juſt like opening the door of a room where muſic was performing. Other methods were tried with better effect. Uniſons were added to each note, which were brought on either by means of pedals or by another ſet of keys.

This method ſucceeded perfectly well, and the power of the harpſichord was greatly improved. But ſtill it was imperfect, becauſe it was only the more conſiderable changes of force which could be exhibited, and this only in one or two degrees. Other artiſts, therefore, attempted to conſtruct the inſtrument, ſo that the jacks (the moveable upright pieces which carry the quills) can be made to approach nearer to the wires, ſo that the quills ſhall give them a ſtronger twang. The mechaniſm was ſuch, that a very conſiderable motion of the pedal produced but a moſt minute motion of the quill; ſo that the performer was not reſtricted to the utmoſt preciſion in the degree of preſſure. Some of thoſe inſtruments, when freſh from the hand of the artiſt, gave full ſatisfaction. But, though made in the moſt accurate manner, at an enormous expence, they very ſoon become unfit for the purpoſe. The hundredth part of an inch, more or leſs, in the place of the quill, will make a great odds in the force of the ſound. Nor does the ſame change of diſtance produce an equal alteration of ſound on different quills. Other inſtrument makers have therefore tried baked or prepared leather (buffalo hide) in place of quills; and it is found much more uniform, in the tone which it produces, and alſo remains longer in the ſame ſtate; but the tone is not ſo powerful, nor in general ſo much reliſhed.

But all theſe contrivances, both in the organ and harpſichord, were ſtill very deficient. Whatever change they could produce in the ſtrength of the ſound, was produced through the whole inſtrument, or at leaſt through two or three octaves. But the captivating expreſſion of muſic frequently reſults from the momentary ſwelling or ſoftening of a ſingle phraſe, or a ſingle note, in one of the parts. Hence ariſe the unrivalled powers of the harp, and the acknowledged ſuperiority of the theorbo, the lute, and even the guitar, over all keyed inſtruments, notwithſtanding their great limitations in harmony and in practicable melodies. Theſe inſtruments ſpeak, while the harpſichord only plays.

Many attempts have been made to enable the performer to produce, by the intervention of the key, all the gradations of ſtrength, and even the varieties of ſound, which the finger can bring forth by the different manner of pinching, bruſhing, or, as it were, careſſing the ſtring; but we have no diſtinct account of any attempt that has ſucceeded. Such a thing would quickly ſpread over Europe. The compiler of the article Luthier, in the *Encyclopedie Methodique*, ſays a great deal about a harpſichord fitted with prepared buffalo leather inſtead of crow quills; and aſſerts expreſsly, that, by the mere preſſure on the key, without the aſſiſtance of pedals or ſtops of any kind, the leather is made to act with greater or leſs force on the ſtring. But he gives no account by which we can comprehend how this is brought about; and indeed he writes in terms which ſhew plainly that he has not ſeen the inſtrument, and is merely puffing ſomething that he does not underſtand.

The attempt has been made with more ſucceſs on keyed inſtruments, when the ſtrings are not pinched, but are rubbed by a wheel or band, in the manner of the vielle (hurdygurdy), or ſtruck with a plectrum, like the dulcimer. The celestina (deſcribed by Merſennus by the name of archiviola) is of this kind. A fine band of horſe hair or ſilk, filled with roſin, is extended under the ſtrings, and drawn ſmoothly along by a wheel. By a particular mechaniſm of the keys, this band is made to preſs or rub on any ſtring tranſverſely, as the ſtrings of a violin are touched by the bow. The preſſure on the key regulates the ſtrength of the tone. This inſtrument is not without conſiderable beauties, and will execute ſoft *cantabile* muſic in eaſy modulation, with great expreſſion and juſtneſs. But the artiſts have not yet been able to give it either clearneſs or brilliancy of tone, nor ſufficient force for concert muſic, nor that promptitude of touch that is indiſpenſibly neceſſary for figurative muſic or quick movements.

The ſame improvements have been made on the pulſatile inſtruments; and indeed they are here the moſt obvious and eaſy. When the key is employed merely as the means of cauſing a plectrum to give a blow to the ſtring, the performer will hardly fail to give that degree of force which he feels proper for his intended expreſſion. Accordingly, many inſtruments of this kind have been made in Germany, where the artiſts have long been eminent for mechanical knacks. But all their inſtruments of the dulcimer kind are feeble and ſpiritleſs, and none of them have been brought into general uſe, if we except the clavichord. This is indeed an inſtrument of feeble, and not the moſt pleaſing ſound; but is well fitted for giving every momentary gradation of ſtrength by the preſſure of the finger. It is therefore a good inſtrument for forming the muſical taſte by chamber practice, and was much uſed by compoſitors in their ſtudies. It is alſo an ingenious, though ſeemingly an obvious and ſimple contrivance, and is capable of much more force, and even brilliancy of ſound, than has generally been given to it.

The conſtruction is ſhortly this. The inner end of the key is furniſhed with an upright piece, which terminates in an edge of braſs, ſomewhat like the end of a narrow blunt chiſel, whoſe line of direction is athwart the ſtrings. When the key is preſſed down, this edge ſtrikes the ſtring, and forces it out of the ſtraight line in which it is ſtretched between its pins. Thus the ſtring is ſhaken or jogged into vibration, in the ſame manner as we obſerve a tight rope ſet a vibrating by a ſudden jerk given to any part of it. The ſtring, thus agitated, gives a ſound, which will continue for ſome little time if the key be held down. As the tone depends on the length of the vibrating ſtring, as well as on its tenſion, it is of importance that the ſtroke be made on the preciſe point of the ſtring which terminates the proper length. The ſtring does not give the note correſponding to its whole length, but that which is produced by the part between the edge and the pin. And becauſe the parts of the ſtring on each ſide of the edge are equally thrown into vibration, the ſhorter portion of it muſt be wrapped up in a liſt of cloth, to prevent it from diſturbing the ear by its ſonorous vibrations. This, however, greatly diminiſhes the ſweetneſs of the ſound given by the other part.

The clavichord gives a fretful waſpiſh kind of ſound, not at all ſuited to tender expreſſion. If the bridge (for the end of the key is really a bridge during the ſound) were placed at an exact third of the length of the ſtring, and if both parts were free, and if the ſtroke be of a proper ſtrength, the ſtring would ſound its twelfth with great ſweetneſs, and with much more force and brilliancy than it does by the preſent conſtruction, and the clavichord would be a charming inſtrument for a leſſon and for private ſtudy. We ſay this from experience of the power of one conſtructed under the direction of the great mathematician Euler, who was alſo an excellent judge of muſic and muſical compoſition. The tones of the upper part of that inſtrument had a ſort of pipe or vocal ſound, and were ſuperior in clearneſs and ſweetneſs to any ſtringed inſtrument we ever heard. But as this conſtruction required every ſtring to be one half longer than a harpſichord wire of the ſame pitch, and as this would have made the inſtrument of a moſt inconvenient ſize, the baſſes were made ſhorter, by placing the bridge at one-ſixth of the length, and loading the ſhorter portion of the ſtring with wire twiſted round it. But although this was executed by a moſt dexterous artiſt, the tones were far inferior to thoſe of the trebles, and the inſtrument was like the junction of a very fine one and a very bad one, and made but hobbling muſic. This was probably owing to the impoſſibility of connecting the metal wire and its covering with ſufficient cloſeneſs and ſolidity. An upright clavichord, where the length would be no inconvenience, would be indeed a capital inſtrument for muſical ſtudy. It is worthy of remark, that Mr Euler tried other diviſions of the ſtring by the bridge. When it is ſtruck preciſely in the middle, it ſhould ſound its octave; when it is ſtruck at one-fourth, it ſhould give the double octave, &c. But the maker found that theſe diviſions give very indifferent, and even uncertain tones; ſometimes not ſounding at all, and ſometimes ſounding beautifully. Our readers will find this well explained in a future article of this *Supplement*, (Trumpet, *Marine*). They may pleaſe to reflect on the very different tone of the violin as it is bowed on different parts of the ſtring, and on the very different tones of the fore and back uniſons, and particularly of the Cornet ſtop of the harpſichord. The harpſichords of Rucker are noted for the grand fulneſs of their tone; thoſe of Haſſe of Dreſden for their mellow ſweetneſs, and thoſe of Kirkmann of London for their unequalled brilliancy. Theſe makers differed greatly in the placing of their quills.

But

Piano Forte.

But the English Piano Forte, by its superior force of tone, its adequate sweetness, and the great variety of voice of which our artists have made it susceptible, has withdrawn all farther attention from the clavichord, so that it is no longer probable that the learned contribution of the great Euler to public amusement will be followed up. The Piano-forte corresponds to its name with great precision: For, without any other attention or effort than what sentiment spontaneously dictates, and what we practise (without knowing it) on the harpsichord, where it is ineffectual, we make the Piano-forte give every gradation of strength to the sound of the string, and give it every expression that an instrument, purely pulsatile, is capable of. It is also susceptible of a very considerable variety of tone by the clothing of the mallets, which may be acute or obtuse, hard or soft. And we see, by the effect of what are called the grand Piano fortes, that they are fully equal to the harpsichord in fulnese or body of tone. Nothing seems to be wanting to it but that sliding, or (as the French call it) *caressing* touch of the string, by which a delicate finger, guided by fine taste, causes the harp or lute to melt the heart, and excite its finest emotions. We trust that the ingenuity of our British artists will accomplish even this, and make this national instrument rival even the violin of Italy.

We call it a *national instrument*, not doubting but that this is a recommendation to a British heart, and because we are very well assured that it is an English contrivance; the invention of a most excellent man and celebrated poet, Mr William Mason. His Caractacus and Elfrida may convince any person who is a judge of music, that he had a mind exquisitely sensible of all its charms; and we cannot be surprised that it was one of his chief delights. No man enjoyed the pleasures of music with more rapture; and he used to say, that his speediest recruit from the fatigue of a long walk was to sit down for a few minutes to the harpsichord. He had seen several of the German attempts to make keyed dulcimers, which were, in some measure, susceptible of the *forte* and *piano*: But they were all on one principle, and required a particular touch of the finger, of difficult acquisition, and which spoiled it for harpsichord practice. We have also seen of those instruments, some of very old date, and others of modern improvement. Some had very agreeable tones; but all were deficient in delicacy and justness. The performer was by no means certain of producing the very strength of sound that he intended. And, as Mr Mason observed, they all required an artificial peculiarity of fingering; without which, either the intended strength of tone was not brought out, or the tone was destroyed by repeated rattling of the mallet on the wire.

Mr Mason removed all those imperfections by detaching the mallet entirely from the key, and giving them a connection quite momentary. The sketch in Plate XL. will give the reader a clear view of Mr Mason's general principle, by which the English piano forte is distinguished from all others. The parts are represented in their state of inaction. The key ABK turns, as usual, on the round edge of the bar B, and a pin *b*, driven into the bar, keeps it in its place. The dot F represents a section of the string. ED is the mallet, having a hinge of vellum, by which it is attached to the upper surface of the bar E. At the other end is the head D, of wood, covered with some folds of prepared leather. The mallet lies in the position represented in the figure, its lower end resting on a cushion-bar K, which lies horizontally under the whole row of mallets. The key AR has a pin C, tipt with a bit of the softest cork or buckskin. This reaches to within $\frac{1}{10}$th of an inch of the shank of the mallet, but must not touch it. The distance E*e* is about $\frac{1}{3}$d or $\frac{1}{4}$th of the length of the shank. When the end A of the key is pressed down on the stuffing (two or three thicknesses of the most elastic woollen list) it raises the mallet, by means of the pin C, to the horizontal position E *d*, within $\frac{1}{8}$th or $\frac{1}{10}$th of an inch of the wire F; but it cannot be so much pressed down as to make the mallet touch the wire. At the same time that the key raises the mallet by means of the pin C, it also lifts off the damper G (a bit of spunge) from the wire. This damper is fixed on the end of a little wooden pin G *g*, connected with the lever *g* H, which has a vellum hinge at H. This motion of the damper is caused by the pin I, which is fixed into the key near to R. These pieces are so adjusted, that the first touch of the key lifts the damper, and, immediately after, the pin C acts on the shank of the mallet. As it acts so near to its centre of motion, it causes the head D to move briskly through a considerable arch D *d*. Being made extremely moveable, and very light, it is thus *tossed* beyond the horizontal position E *d*, and it strikes the wire F, which is now at liberty to vibrate up and down, by the previous removal of the damper G. Having made its stroke, the mallet falls down again, and rests on the soft substance on the pin C. It is of essential importance that this mallet be extremely light. Were it heavy, it would have so much force, after rebounding from the wire, that it would rebound again from the pin C, and again strike the wire. For it will be recollected, that the key is, at this time, down, and the pin C raised as high as possible, so that there is very little room for this rebound. Lessening the momentum of the mallet by making it very light, making the cushion on the top of the pin C very soft, and great precision in the shape and figure of all the parts, are the only securities against the disagreeable rattling which these rebounds would occasion. In respect to the solidity and precision of workmanship, the British instruments are unrivalled, and vast numbers of them are sent to all parts of the continent.

As the blow of so light a mallet cannot bring much sound from a wire, it has always been found necessary to have two strings for each note. Another circumstance contributes to enfeeble the sound. The mechanism necessary for producing it makes it almost impossible to give any considerable extent to the belly or sound board of the instrument. There is seldom any more of it than what occupies the space between the tuning pins and the bridge. This is the more to be regretted, because the basses are commonly covered strings, that they may be of a moderate length. The bass notes are also of brass, which has a considerably lower tone than a steel wire of the same diameter and tension. Yet even this substitution for steel in the bass strings is not enough. The highest of them are much too slack, and the lowest ones must be loaded, to compensate for want of length. This greatly diminishes the fulness, and still more the mellowness and distinctness of the tone, and frequently makes the very lowest notes hardly appreciable. This inequality of tone about the

Pigments.

the middle of the inftrument is fomewhat diminifhed by conftructing the inftrument with two bridges; one for the fteel, and the other for the brafs wires. But ftill the bafs notes are very much inferior to the treble. It would furely be worth while to conftruct fome piano fortes, of full fize, with naked baffes. If thefe were made with all the other advantages of the grand piano forte, they would furpafs all other inftruments for the regulating power of their thorough bafs. We wifh that the artifts would alfo try to conftruct them with the mechanifm of mallets, &c. above the found board. This would allow to it the full extent of the inftrument, and greatly improve the tone. It does not feem impoffible, nor (we think) very difficult.

For directions how to tune this pleafing inftrument, fee TEMPERAMENT in this *Supplement*.

PIGMENTS, or PAINTS, are furnifhed by both the mineral and vegetable kingdoms. The former are the moft durable, and are generally prepared from the OXIDES of metals (fee CHEMISTRY-*Index* in this *Suppl.* and *COLOUR-Making*, Encycl.); but Fourcroy thinks that chemiftry furnifhes a method of fixing vegetable colours completely. From a number of experiments, which we need not detail, as they will be noticed in the article *Vegetable* SUBSTANCES; he draws the following conclufions:

1. That oxygen, when combined with vegetable fubftances, changes their colour.

2. That different proportions of this principle produce different fhades in coloured vegetable matter.

3. That thefe fhades pafs, by a fort of degradation, from the darkeft colours to the lighteft; and that the extreme point of the latter may be confidered as a complete deprivation of colour.

4. That in many vegetable fubftances this degradation does not take place, as M. Berthollet has obferved.

5. That many red, violet, purple, chefnut, and blue vegetable colours, are produced by different proportions of oxygen; but that none of thefe are completely faturated with this principle.

6. That the complete faturation here fpoken of generally produces yellow colours, which are the leaft changeable of all.

7. That vegetable fubftances coloured by oxygen, not only change their colour according to the proportion of oxygen they have imbibed, but that they alfo change their nature in the fame proportion, and approach more to a refinous ftate as they become nearer to a yellow colour.

Laftly, that the caufe of the changeability of the red, brown, and violet colours, procured from vegetables, is fuch as has been ftated above; that there exifts a method of fixing them, or rendering them permanent, by impregnating them with a certain quantity of oxygen, by means of the oxygenated muriatic acid; imitating, by this procefs, the method purfued by nature, who never forms fixed and permanent colours, except in fubftances which have been long expofed to the open air.

Pitch, Plague.

PITCH. See *Encycl.*—The beft black pitch is made of the refufe of rofin and turpentine, fuch as will not pafs through the ftraw filter, and the cuttings around the incifion on the tree. Thefe materials are put into a boiler fix or feven feet in circumference, and eight or ten high. Fuel is laid around the top, and the materials as they melt flow through a channel cut in the fire-place into a tub half filled with water. It is at that time very red, and almoft liquid. To give this a proper confiftence, it is put in a cauldron placed in a furnace, and boiled down in the fame manner as rofin, but it requires much lefs precaution and double the time. It is then poured into moulds of earth, and forms the beft kind of black pitch. See ROSIN and TURPENTINE in this *Suppl.*

BASTARD PITCH, is a mixture of colophony, black pitch, and tar boiled down together, and caft in moulds.

PLAGUE (fee MEDICINE-*Index*, Encycl.), is a difeafe which has been lately afferted by Dr Mofeley to be not contagious. In fupport of this opinion, he quotes many paffages from medical writers, ancient and modern; but he feems to place the greateft confidence (as is indeed natural) in his own obfervations on peftilential fevers in the Weft Indies, and on what is faid of the plague in Berthier's account of Buonaparte's expedition into Syria.

"At the time of our entry into Syria (fays this Frenchman), all the towns were infected by the plague; a malady which ignorance and barbarity render fo fatal in the Eaft. Thofe who are affected by it give themfelves up for dead; they are immediately abandoned by every body (A), and are left to die, when they might have been faved by medicine and attention.

"Citizen Degenettes, principal phyfician to the army, difplayed a courage and character which entitle him to the national gratitude. When our foldiers were attaked by the leaft fever, it was fuppofed that they had caught the plague, and thefe maladies were confounded. The fever hofpitals were abandoned by the officers of health and their attendants. Citizen Degenettes repaired in perfon to the hofpitals, vifited all the patients, felt the glandular fwellings, dreffed them, declared and maintained that the diftemper was not the plague, but a malignant fever with glandular fwellings, which might eafily be cured by attention, and keeping the patient's mind eafy."

Degenette's views in making this diftinction were highly commendable; but certainly, fays Dr Mofeley, this fever was the plague. The phyfician, however, carried his courage fo far, as to make two incifions, and to inoculate the fuppurated matter from one of thefe buboes above his breaft and under his arm-pits, but was not affected with the malady. He thus eafed the minds of the foldiers, the firft ftep to a cure; and, by his affiduity and conftant attendance in the hofpitals, a number of men attacked with the plague were cured. His example was followed by other officers of health.

The lives of a number of men Citizen Degenettes was

(A) This can hardly be true. Every one knows that Mahometans are fatalifts in the ftricteft fenfe of the word; and Mr Browne, whofe knowledge of Syria and its inhabitants muft be at leaft equal to that of Berthier, affures us, that, far from abandoning his friend in the plague, "the Moflem, awe-ftruck, and refigned to the unalterable decrees of fate, hangs over the couch of his expiring relative."

Plague.

was thus instrumental of saving. He dismissed those who had been ill with the fever and buboes, without the least contagion being communicated to the army.

"There are (says Dr Moseley) annual or seasonal disorders, more or less severe, in all countries; but the plague, and other great depopulating epidemics, do not always obey the seasons of the year. Like comets, their course is eccentric. They have their revolutions; but from whence they come, or whither they go after they have made their revolutions, no mortal can tell.

"To look for the cause of an epidemic in the present state of the air, or weather, when it makes its appearance, is a very narrow contracted method of scrutiny. The cause of pestilential epidemics cannot be confined, and local. It must lie in the atmosphere, which surrounds, and is in contact with every part of us; and in which we are immersed, as bodies in fluids.

"These diseases not appearing in villages and thinly inhabited places, and generally attacking only great towns and cities, may be, that the atmosphere, which I conceive to be the universal propagator of pestilence, wants a commixture, or union, with some compounded and peculiar air, such as is generated in populous communities, to release its imprisoned virulence, and give it force. Like the divided seminal principles of many plants, concealed in winds and rains until they find suitable materials and soil to unite their separated atoms, they then assume visible forms in their own proper vegetation.

"Diseases originating in the atmosphere seize some, and pass by others; and act exclusively on bodies graduated to receive their impressions; otherwise whole nations would be destroyed. In some constitutions of the body the access is easy, in some difficult, and in others impossible.

"The air of confined places may be so vitiated as to be unfit for the purposes of the healthy existence of any person. Hence gaol, hospital, and ship fevers. But, as these distempers are the offspring of a local cause, that local cause, and not the distempered people, communicate the disease.

"Plagues and pestilences, the produce of the great atmosphere, are conveyed in the same manner, by the body being in contact with the cause; and not by its being in contact with the effect. If pestilences were propagated by contagion, from infected persons, the infection must issue from their breath or excrements, or from the exhalations of the bodies of the diseased. The infection, if it were not in the atmosphere, would be confined within very narrow limits; have a determinate sphere of action; and none but physicians and attendants on the sick would suffer; and these must suffer; and the cause and the effects would be palpable to our senses. Upon this ground the precaution of quarantine would be rational. But who then would visit and attend the sick, or could live in hospitals, prisons, and lazarettos?"

From these reasonings and facts, the author is convinced, that the bubo and carbuncle, of which we hear so much in Turkey, and read so much in our own history of plagues, arise from heating food and improper treatment; that they contain no infection; and consequently that they are not the natural deposit of the morbific virus separated from the contagion.

He is equally confident that no pestilential or pandemic fever was ever imported or exported; and hence he considers the fumigating of ship-letters, and shutting up the crews and passengers of vessels, on their arrival from foreign places, several weeks, for fear they should give diseases to others which they have not themselves, as an ignorant barbarous custom. Whence was the importation of the plague at Naples in 1656; by which 20,000 people died in one day? Can any person, for a moment reflecting, believe, that the great plague of London in 1665, which imagination traced from the Levant to Holland, and from Holland to England, was caused by opening a bag of cotton in the city, or in Long Acre; or a package of hemp in St Giles's parish? Quarantine, always expensive to commerce, and often ruinous to individuals, is a reflection on the good sense of countries.

That Dr Moseley is a man of learning, and a lively writer, is known to every one who has looked into his works, and is not himself a stranger to letters. On this account, and still more on account of the opportunities which he has possessed of making accurate observations on various kinds of pestilential diseases, we have detailed at some length his notions of the plague; but as it does not appear that he ever *saw* the disease which is *known* by the name of *the plague*, justice requires that we give some account of it from a man who had the best possible opportunities of obtaining correct information on the subject.

"The facts that appear to be chiefly ascertained relative to the plague (says Mr Browne), are, 1. That the infection is not received but by actual contact. In this particular, it would seem less formidable than several other disorders. 2. That it is communicated by certain substances, by others not; as by a woollen cloth, or rope of hemp, but not by a piece of ivory, wood, or rope made of the date tree; nor by any thing that has been completely immersed in water. It would appear from the report of the Kahirines *, that no animal but man is affected with this disorder; though, it is said, a cat passing from an infected house has carried the contagion. 3. That persons have often remained together in the same house, and entirely under the same circumstances, of whom one has been attacked and died, and the others never felt the smallest inconvenience. 4. That a person may be affected any number of times. 5. That it is more fatal to the young than the old. 6. That no climate appears to be exempt from it; yet, 7. That the extremes of heat and cold both appear to be adverse to it. In Constantinople it is often, but far from being always, terminated by the cold of winter, and in Kahira by the heat of summer; both circumstances being, as may be conjectured, the effect of indisposition for absorption in the skin, unless it be supposed that in the latter case it may be attributed to the change the air undergoes from the increase of the Nile.

* The inhabitants of *Cairo*, which Mr Brown uniformly calls *Kahira*.

"The first symptoms are said to be thirst; 2. Cephalalgia; 3. A stiff and uneasy sensation, with redness and tumor about the eyes; 4. Watering of the eyes; 5. White pustules on the tongue. The more advanced symptoms of buboes, fœtor of the breath, &c. &c. are well known; and I have nothing authentic to add to them. Not uncommonly, all these have successively shewn themselves, yet the patient has recovered; in which case, where suppuration has had place, the skin always remains discoloured, commonly of a purple hue. Many who have been bleeded in an early stage of the disorder,

disorder, have recovered without any fatal symptoms; but whether from that or any other cause, does not appear certain (B). The same operation is reported to have been commonly fatal in a late stage. It is said that embrocating the buboes continually with oil has sometimes wrought a cure; but this remedy is so difficult and dangerous for the operator, that it would appear experiments must yet be very defective."

They are not, perhaps, so defective as Mr Browne supposes. In the hospital of St Anthony at Smyrna, it has been the practice for many years past to rub over with warm olive oil the bodies of persons infected by the plague; and that practice has been attended with wonderful success. It was first suggested by Mr Baldwin the English consul; and from him adopted by *P. Luigi di Pavia*, who for upwards of 27 years has exposed himself to infection by his unremitting attendance on those who are labouring under this dreadful distress. This excellent man, whose philanthropy equals that even of "Marseilles' good bishop," declares, that during the long period mentioned, he has found no remedy comparable to that of rubbing olive oil, with the strongest friction, into the whole body of the infected person. When the body is thus rubbed, the pores being opened, imbibe the oil, and a profuse perspiration takes place, by which the poisonous infection is again thrown out. This operation must be performed the first day of the infection; and if only a weak perspiration ensues, it must be repeated till it is observed that every particle of infection is removed, and that the whole body of the patient is covered with a profuse sweat. Neither the patient's shirt nor bed-clothes must be changed till the perspiration has entirely ceased. The operation must be performed in a very close apartment; and at every season of the year there must be kept in it a fire-pan, over which sugar and juniper must be thrown from time to time, that the vapour which thence arises may promote the perspiration. The whole body of the patient, the eyes alone excepted, must in this manner be anointed, or rather rubbed over, with the greatest care.

This practice of the pious monk is mentioned by Mr Howard in his work on Lazarettos; but a more satisfactory account of it is given by Count *Leopold von Berchtold*, who adds the following remarks by way of illustration: 1. The operation of rubbing in the oil must be performed by means of a sponge, and so speedily as not to last more than about three minutes. 2. The interval between the first and the second rubbing, if a second be necessary, must be determined by circumstances, as the second must not be performed till the first perspiration is over, and this will depend on the constitution of the patient. If any sweat remains upon the skin, it must be wiped off with a warm cloth before the second rubbing takes place. This strong friction with oil may be continued for several days successively, until a favourable change is remarked in the disease; after which the rubbing may be performed in a more gentle manner. The quantity of oil requisite each time cannot be determined with accuracy; but, in general, a pound may be sufficient. The purest and freshest oil is the best for this operation: it must not be hot, but only lukewarm. The breast and privities must be rubbed softly. In a cold climate such as ours, those parts only into which the oil is rubbed must be exposed naked. The other parts must be covered with warm clothing. In this manner each part of the body must be rubbed with oil in succession, as quickly as possible, and be then instantly covered. If the patient has boils or buboes, they must be rubbed over gently with the oil till they can be brought to suppurate by means of emollient plasters. The persons who attend the patients to rub in the oil must take the precaution to rub themselves over in the like manner, before they engage in the operation. They must, if possible, avoid the breath of the patient, and not be under any apprehensions of catching the infection.

P. Luigi then says: "In order to prevent the patients from losing their strength, I prescribed for them, during four or five days, soup made of vermicelli boiled in vinegar without salt. I gave them six or seven times a-day a small spoonful of preserved sour cherries; preserved not with honey, but with sugar, as the former might have occasioned a diarrhœa. When convinced that the patients were getting better, I usually gave them the fifth morning a cup of good Mocha coffee, with a piece of toasted biscuit (*biscotto*) prepared with sugar; and I doubled the latter according to the strength and improvement of my patients."

In the course of five years, during which friction with oil was employed in the hospital at Smyrna, of 250 persons attacked by the plague the greater part were

(B) Dr Moseley, we think, has assigned a very sufficient reason why bleeding should generally prove effectual, if recourse be had to it at the commencement of the disease. "In the common order of pestilential fevers (says he), they commence with coldness and shivering; simply demonstrating, that something unusual has been in contact with the skin, agonizing cutaneous sensibility. Sickness at the stomach, and an immoveable pressure about the præcordia, follow. These demonstrate, that the blood cannot pervade the extremities of the body, and that the quantity which ought to dilate through the whole machine is confined to the larger organs, and is crowding and distending the heart and central vessels.

"The restraining power of the remoter blood vessels being destroyed, the thinner parts of the blood escape their boundaries; hence arises yellowness in the skin in some climates; in others, the extravasated grosser parts of the blood stagnate, forming black lodgements, bubo, anthrax, and exanthemata.

"The object in these fevers is, to decide the contest between the solids and the fluids; and this appears to me to be only practicable, when spontaneous sweats do not happily appear, or cannot be raised by a cooling regimen; and by draining the vital parts, by bleeding and purging, before the fluids have burst their confines, and dissolved their bond of union with the solids. The next step is to regain the lost energy of the surface of the body, by exciting perspiration; and then of the whole system, by tonics.

"When these things are not done in the first hours of attack, in pestilential fevers, and the conflict is not *extinguished* at once, attempting to extort sweats from the body, by heating alexapharmacs, will do mischief; and bark, wine, stimulants, and cordials, may be called on, like undertakers, to perform an useless ceremony."

Planetary-hours, Planets.

were cured; and this would have been the cafe with the reft had they not neglected the operation, or had it not been employed too late after their nervous fyftem had been weakened by the difeafe fo as to render them incurable. Immenfe numbers of people have been preferved from the effects of this malady by the above means; and of all thofe who have anointed themfelves with oil, and rubbed it well into their bodies, not one has been attacked by the plague, even though they approached perfons already infected, provided they abftained from heavy and indigeftible food.

Thus we fee, if this account may be depended on, that oil rubbed into the fkin acts as a preventative, as well as a cure. When the operation is performed to prevent infection, and it is fuccefsfully performed with that view at Smyrna, as often as the plague makes its appearance in the city, as it is not done for the purpofe of promoting perfpiration, it is not requifite that it fhould be performed with the fame fpeed as when for curing the diforder; nor is it neceffary to abftain from flefh and to ufe foups; but it will be proper to ufe only fowls or veal for ten or twelve days, boiled or roafted, without any addition or feafoning (*condimento*). In the laft place, it will be neceffary to guard againft fat and indigeftible food, and fuch liquors as might put in motion or inflame the mafs of the blood.

This important difcovery deferves the ferious confideration of all medical men; for if olive oil has been found efficacious in curing or preferving againft one fpecies of infection, it is not abfurd to fuppofe that the fame or other kinds of oil might be productive of much benefit in other malignant infectious difeafes. We hope foon to hear of fome trial being made with it in this country. Would it be of any fervice in the yellow fever, fo prevalent in the weftern world? See the *Philofophical Magazine*, Vol. II.

PLANETARY HOURS, are twelfth parts of the artificial day and night; being each double in length to the hour ufed in civil computation in Europe. They are ftill ufed by the Jews as they were among their forefathers; and hence are called *Jewifh* hours. The reafon of their being called *planetary* hours, is, that according to the aftrologers, a new planet comes to predominate every hour, and that the day takes its denomination from that which predominates the firft hour of it; as Monday from the moon, &c.

PLANETS have been fufficiently defcribed in the articles ASTRONOMY in the *Encyclopædia* and this *Supplement*. The word is introduced here merely to notice the difcovery of two new planets fince thofe articles were written. The firft was difcovered in January 1801, by Piazzi of Palermo; and the other, if it be indeed a planet, on the 28th of March 1802, by Mr Olbars an aftronomer of Bremen. Of the exiftence of Piazzi's planet there is no doubt, as it has been obferved by almoft all the eminent aftronomers of Europe. Its orbit is between that of Mars and Jupiter, and its appearance like that of a ftar of the feventh or eighth magnitude. It has been called *Juno*, *Hera*, and *Ceres Ferdinandea*. The laft of thefe names feems to be generally adopted; and it was impofed by the difcoverer in allufion to Sicily, and the monarch who reigns over that country. Dr Herfchel does not think the ftar of Olbars intitled to the rank of a planet; and hitherto we believe it has received no name. *Ceres Ferdinandea* revolves in four years; and the following are the elements found by Bruckhardt and Gaufs, and admitted by Lalande:

Inclination	10° 47′	Inclination	10° 36′ 57″
Node	2s 20 58	Node	2s 21 0 44
Aphelion	2 9 0	Epoch	2 16 28 0
Paffage of the Aph.		Mean anom.	3 15 55
Jan. 1. 1801	8 hours	Aphelion	10 26 27 58
Eccentricity	0.0364	Eccentricity	0.0825017
Semi-axis	2.574	Equation	9° 28′
Revolution	4.13 years	Diftance	2.73555

Plants.

PLANTS, organifed bodies, of which a full account has been given in the *Encycl.* under the title BOTANY, PLANTS, SEXES, &c. The eftablifhment of the fexual fyftem in vegetables, and the acknowledged analogy between vegetable and animal bodies, has fuggefted a method of improving plants, as animals are confeffedly improved, by what is called *croffing the breed*. This thought incurred firft, we believe, to Andrew Knight, Efq; and in the Tranfactions of the Royal Society for 1799, we have an account of fome very curious experiments made by him, with the view of afcertaining whether the improvement which he had conceived be actually practicable. Thofe were chiefly made on the garden pea, of which he had a kind growing in his yard; which having been long cultivated in the fame foil, had ceafed to be productive, and did not appear to recover the whole of its former vigour when removed to a foil of a fomewhat different quality. On this his firft experiment in 1787 was made. Having opened a dozen of its immature bloffoms, he deftroyed the male parts, taking great care not to injure the female ones; and a few days afterwards, when the bloffoms appeared mature, he introduced the farina of a very large and luxuriant grey pea into one half of the bloffoms, leaving the other half as they were. The pods of each grew equally well; but he foon perceived that of thofe into whofe bloffoms the farina had not been introduced, the feed remained nearly as they were before the bloffom expanded, and in that ftate they withered. Thofe in the other pods attained maturity, but were not in any fenfible degree different from thofe afforded by other plants of the fame variety; owing, he imagines, to the external covering of the feed (as he had found in other plants) being furnifhed entirely by the female. In the fucceeding fpring, the difference, however, became extremely obvious; for the plants from them arofe with exceffive luxuriance, and the colour of their leaves and ftems clearly indicated that they had all exchanged their whitenefs for the colour of the male parent: the feeds produced in autumn were dark grey. By introducing the farina of another white variety (or in fome inftances by fimple culture), he found this colour was eafily difcharged, and a numerous variety of new kinds produced; many of which were in fize and every other refpect much fuperior to the original white kind, and grew with exceffive luxuriance, fome of them attaining the height of more than twelve feet.

The diffimilarity he obferved in the offspring, afforded by different kinds of farina in thefe experiments, pointed out to him an eafy method of afcertaining whether fuperfœtation (the exiftence of which has been admitted among animals) could alfo take place in the vegetable world. For as the offspring of a white pea is always white, unlefs the farina of a coloured kind be introduced into the bloffom, and as the colour of the grey one is always transferred to its offspring, though the female be white, it readily occurred to Mr Knight, that if the farina of both were mingled or applied at the fame moment, the offspring of each could be eafily diftinguifhed.

His firft experiment was not altogether fuccefsful; for the offspring of five pods (the whole which efcaped the birds) received their colour from the coloured male. There was, however, a ftrong refemblance to the other male in the growth and character of more than one of the plants; and the feeds of feveral in the autumn very clofely refembled it in every thing but colour. In this experiment he ufed the farina of a white pea, which poffeffed the remarkable property of fhrivelling excef-fively when ripe; and in the fecond year he obtained white feeds from the grey ones above mentioned, perfectly fimilar to it. He is therefore ftrongly difpofed to believe that the feeds were here of common parentage; but doth not conceive himfelf to be in poffeffion of facts fufficient to enable him to fpeak with decifion on this queftion. We have no right to form a decided opinion on this part of the fubject, having paid to it very little attention; but at prefent we are inclined to think differently from the author. We admit, indeed, that if the female afford the firft organized atom, and the male act only as a ftimulus, it is by no means impoffible that the explofion of two veficles of farina, at the fame moment (taken from different plants), may afford feeds of common parentage; but whether the female or the male affords the firft organized atom, is the queftion which to us appears not yet decided.

Another fpecies, however, of fuperfœtation, in which one feed appears to have been the offspring of two males, has occurred to Mr Knight fo often, as to remove, he fays, all poffibility of doubt as to its exiftence. In 1797, the year after he had feen the refult of the laft mentioned experiment, having prepared a great many white bloffoms, he introduced the farina of a white and that of a grey nearly at the fame moment into each; and as in the laft year the character of the coloured male had prevailed, he ufed its farina more fparingly than that of the white one; and now almoft every pod afforded plants of different colours. The majority, however, were white; but the characters of the two kinds were not fufficiently diftinct to allow him to judge with precifion whether any of the feeds were produced of common parentage or not. In the year 1798 he was more fortunate; having prepared bloffoms of the little early frame pea, he introduced its own farina, and immediately afterwards that of a very large and late grey kind, and fowed the feeds thus obtained in the end of fummer. Many of them retained the colour and character of the fmall early pea, not in the flighteft degree altered, and bloffomed before they were eighteen inches high; whilft others (taken from the fame pods), whofe colour was changed, grew to the height of more than four feet, and were killed by the froft before any bloffoms appeared.

It is evident, that in thefe inftances fuperfœtation took place; and it is equally evident that the feeds were not all of common parentage. Should fubfequent experience evince, that a fingle plant may be the offfpring of two males, the analogy between animal and vegetable nature may induce fome curious conjectures relative to the procefs of generation in the animal world.—It certainly may; but either we do not perfectly underftand the author's meaning, or this experiment is not conclufive. There were here feeds of different colours produced by the farina of different males, operating on the fame female plant; and there are well attefted inftances of twin children being born of different colours, in confequence of the coition of different males, a negro and a white man, with the fame woman. Had Mr Knight difcovered, not that the fame pod, but that the fame individual *pea*, was the offspring of two males, his difcovery would indeed have led to fome curious conjectures refpecting animal generation. But to proceed with his experiments.

By introducing the farina of the largeft and moft luxuriant kinds into the bloffoms of the moft diminutive, and by reverfing this procefs, he found that the powers of the male and female, in their effects on the offspring, are exactly equal. The vigour of the growth, the fize of the feeds produced, and the feafon of maturity, were the fame, though the one was a very early and the other a late variety. He had in this experiment a ftriking inftance of the ftimulative effects of croffing the breeds; for the fmalleft variety, whofe height rarely exceeded two feet, was increafed to fix feet; whilft the height of the large and luxuriant kind was very little diminifhed. By this procefs it is evident, that any number of new varieties may be obtained; and it is highly probable, that many of thefe will be found better calculated to correct the defects of different foils and fituations than any we have at prefent.

The fuccefs of Mr Knight's experiments on the pea induced him to make fimilar experiments on wheat; but thefe did not anfwer his expectations. The varieties indeed which he obtained, efcaped the blights of 1795 and 1796; but their qualities were not otherwife good, nor were they permanent. His experiments on the apple, the improvement of which was the firft object of his attention, have, as far as he could judge from the cultivated appearance of trees which had not borne fruit when he wrote his memoir, been fully equal to his hopes. The plants which he obtained from his efforts to unite the good qualities of two kinds of apple, feem to poffefs the greateft health and luxuriance of growth, as well as the moft promifing appearance in other refpects. In fome of thefe the character of the male appears to prevail; in others that of the female; and in others both appear blended, or neither is diftinguifhable. Thefe variations, which were often obfervable in the feeds taken from a fingle apple, evidently arife from the want of permanence in the character of this fruit, when raifed from feed. Many experiments of the fame kind were tried on other plants; but it is fufficient to fay, that all tended to evince, that improved varieties of every fruit and of efculent plants may be obtained by this procefs, and that Nature intended that a fexual intercourfe fhould take place between neighbouring plants of the fame fpecies. For the nutrition of plants, fee VEGETABLE SUBSTANCES in this *Suppl.*

PLATINUM, or PLATINA (See CHEMISTRY, *Suppl.* Part I. Chap. iii. Sect. 3.), is a metal, of which every chemift regrets the difficulty of making it malleable. Of the different proceffes adopted to accomplifh this end, we have reafon to believe that of Mr Richard Knight the moft fuccefsful; and, with the ſpirit of a true philoſopher, he wiſhes to make that proceſs as generally known as poſſible. We ſhall give it in his own words:

"To a given quantity of crude platinum, I add (ſays he) 15 times its weight of nitro-muriatic acid (compoſed of equal parts of nitric and muriatic acids) in a tubulated glaſs retort, with a tubulated receiver adapted to it. It is then boiled, by means of an Argand's lamp, till the acid has aſſumed a deep ſaffron colour: it is then poured off; and if any platina remains undiſſolved, more acid is added, and it is again boiled until the whole is taken up. The liquor, being ſuffered to reſt till quite clear, is again decanted: a ſolution of ſal-ammoniac is then added, by little and little, till it no longer gives a cloudineſs. By this means the platina is thrown down in the form of a lemon-coloured precipitate, which having ſubſided, the liquor is poured off, and the precipitate repeatedly waſhed with diſtilled water till it ceaſes to give an acid taſte (too much water is injurious, the precipitate being in a certain degree ſoluble in that liquid); the water is then poured off, and the precipitate evaporated to dryneſs."

Thus far our author's method, as he candidly obſerves himſelf, differs not from that which has been followed by many others; but the remainder of the proceſs is his own. "A ſtrong, hollow, inverted cone of crucible earth being procured, with a correſponding ſtopper to fit it, made of the ſame materials, the point of the latter is cut off about three-fourths from the baſe. The platina, now in the ſtate of a light yellow powder, is preſſed tight into the cone, and, a cover being fixed ſlightly on, it is placed in an air furnace, and the fire raiſed gradually to a ſtrong white heat. (The furnace uſed by Mr Knight is portable, with a chamber for the fire only eight inches in diameter.) In the mean time the conical ſtopper, fixed in a pair of iron tongs ſuitable for the purpoſe, is brought to a red, or to a bright red, heat. The cover being then removed from the cone, the tongs with the heated ſtopper is introduced through a hole in the cover of the furnace, and preſſed at firſt gently on the platina, at this time in a ſtate nearly as ſoft as dough, till it at length acquires a more ſolid conſiſtence. It is then repeatedly ſtruck with the ſtopper, as hard as the nature of the materials will admit, till it appears to receive no farther impreſſion. The cone is then removed from the furnace; and being ſtruck lightly with a hammer, the platina falls out in a metallic button, from which ſtate it may be drawn, by repeatedly heating and gently hammering, into a bar fit for flatting, drawing into wire, planiſhing, &c.

"Beſides the comparative facility of this proceſs, it has the farther advantage of rendering the platina much purer than when red hot iron is obliged to be had recourſe to; for platina, when of a white heat, has a ſtrong affinity for iron, and, with whatever care it may have been previouſly ſeparated from that metal, will be found to have taken up a portion of it, when it is employed of a red heat, to ſerve to unite the particles of the platina."

PLATONIC Bodies, ſee *Regular Bodies*, *Suppl.*

PLUVIAMETER, a machine for meaſuring the quantity of rain that falls, otherwiſe called Ombrometer; which ſee, *Encycl.*

POLLARDS, the name of a coarſe kind of wheaten flour. When the flour of wheat is ſeparated into three degrees of fineneſs, the third is the pollards. There is nothing between it and the bran.

PORCELAIN, a kind of earthen or ſtone ware, of the manufacture of which a full account is given in the *Encyclopædia* from Groſier and Reaumur. It may be proper, however, to add here, from Sir George Staunton, that one of the principal ingredients in the Chineſe porcelain called *pe-tun-tſe*, is a ſpecies of fine granite, or compound of quartz, feldſpath, and mica, in which the quartz bears the largeſt proportion. "It appears (ſays Sir George) from ſeveral experiments, that *pe-tun-tſe* is the ſame as the growan-ſtone of the Corniſh miners. The micaceous part in ſome of this granite from both countries, often contains ſome particles of iron; in which caſe it will not anſwer the potter's purpoſe. This material can be calcined and ground much finer by the improved mills of England, than by the very imperfect machinery of the Chineſe, and at a cheaper rate, than the prepared *pe-tun-tſe* of their own country, notwithſtanding the cheapneſs of labour there. The *kao-lin*, or principal matter mixed with the *pe-tun-tſe*, is the growan clay alſo of the Corniſh miners. The *wha-ſhe* of the Chineſe is the Engliſh ſoap rock; and the *ſhe kan* is aſſerted to be gypſum.

"The manufacture of porcelain is ſaid to be precarious, from the want of ſome preciſe method of aſcertaining and regulating the heat within the furnaces, in conſequence of which, their whole contents are baked ſometimes into one ſolid and uſeleſs maſs." If this be ſo, Wedgewood's thermometer would be a preſent highly valuable to the Chineſe potter, if that arrogant and conceited people would condeſcend to be taught by a native of Europe.

POSITION, Centre of, is a point of any body, or ſyſtem of bodies, ſo ſelected, that we can eſtimate with propriety the ſituation and motion of the body or ſyſtem by the ſituation and motion of this point. It is very plain that, in all our attempts to accurate diſcuſſion of mechanical queſtions, eſpecially in the preſent extended ſenſe of the word *mechaniſm*, ſuch a ſelection is neceſſary. Even in common converſation, we frequently find it neceſſary to aſcertain the diſtance of objects with a certain preciſion, and we then perceive that we muſt make ſome ſuch ſelection. We conceive the diſtance to be mentioned, neither with reſpect to the neareſt nor the remoteſt point of the object, but as a ſort of average diſtance; and we conceive the point ſo aſcertained to be ſomewhere about the middle of the object. The more we reflect on this, we find it the more neceſſary to attend to many circumſtances which we had overlooked. Were it the queſtion, to decide in what preciſe part of a country pariſh the church ſhould be placed, we find that the geometrical middle is not always the moſt proper. We muſt conſider the populouſneſs of the different quarters of the pariſh, and ſelect a point ſuch, that the diſtances of the inhabitants on each ſide, in every direction, ſhall be as equally balanced as poſſible.

In mechanical diſcuſſions, the point by whoſe poſition and diſtance we eſtimate the poſition and diſtance of the whole, muſt be ſo ſelected, that its poſition and diſtance, eſtimated in any direction whatever, ſhall be the average of the poſitions and diſtances of every particle of the aſſemblage, eſtimated in that direction.

This will be the caſe, if the point be ſo ſelected that, when a plane is made to paſs through it *in any direc-*

Position. *tion whatever*, and perpendiculars are drawn to this plane from every particle in the body or syſtem, the ſum of all the perpendiculars on one ſide of this plane is equal to the ſum of all the perpendiculars on the other ſide. If there be ſuch a point in a body, the poſition and motion of this point is the average of the poſitions and motions of all the particles.

Plate XL. For if P (fig. 1.) be a point ſo ſituated, and if QR be a plane (perpendicular to the paper) at any diſtance from it, the diſtance Pp of the point from this plane is the average of the diſtances of all the particles from it. For let the plane APB be paſſed through P, parallel to QR. The diſtance CS of any particle C from the plane QR is equal to DS—DC, or to Pp—DC. And the diſtance GT of any particle G, lying on the other ſide of APB, is equal to HT+GH, or to Pp+GH. Let n be the number of particles on that ſide of AB which is neareſt to QR, and let o be the number of thoſe on the remote ſide of AB, and let m be the number of particles in the whole body, and therefore equal to $n+o$. It is evident that the ſum of the diſtances of all the particles ſuch as C, is n times Pp, after deducting all the diſtances, ſuch as DC. Alſo the ſum of all the diſtances of the particles, ſuch as G, is o times Pp, together with the ſum of all the diſtances, ſuch as GH. Therefore the ſum of both ſets is $\overline{n+o}\times Pp +$ ſum of GH—ſum of DC, or $m\times Pp+$ ſum of GH—ſum of DC. But the ſum of GH, wanting the ſum of DC, is nothing, by the ſuppoſed property of the point P. Therefore $m\times Pp$ is the ſum of all the diſtances, and Pp is the mth part of this ſum, or the average diſtance.

Now ſuppoſe that the body has changed both its place and its poſition with reſpect to the plane QR, and that P (fig. 2.) is ſtill the ſame point of the body, and α P β a plane parallel to QR. Make $p\,\pi$ equal to p P of fig. 1. It is plain that Pp is ſtill the average diſtance, and that $m\times Pp$ is the ſum of all the preſent diſtances of the particles from QR, and that $m\times \pi p$ is the ſum of all the former diſtances. Therefore $m\times P\pi$ is the ſum of all the changes of diſtance, or the whole quantity of motion eſtimated in the direction π P. Pπ is the mth part of this ſum, and is therefore the average motion in this direction. The point P has therefore been properly ſelected; and its poſition, and diſtance, and motion, in reſpect of any plane, is a proper repreſentation of the ſituation and motion of the whole.

It follows from the preceding diſcuſſion, that if any particle C (fig. 1.) moves from C to N, in the line CS, the centre of the whole will be transferred from P to Q, ſo that PQ is the mth part of CN; for the ſum of all the diſtances has been diminiſhed by the quantity CN, and therefore the average diſtance muſt be diminiſhed by the mth part of CN, or PQ is $=\frac{CN}{m}$.

But it may be doubted whether there is in every body a point, and but one point, ſuch that if a plane paſs through it, *in any direction whatever*, the ſum of all the diſtances of the particles on one ſide of this plane is equal to the ſum of all the diſtances on the other.

It is eaſy to ſhew that ſuch a point may be found, with reſpect to a plane parallel to QR. For if the ſum of all the diſtances DC exceed the ſum of all the diſtances GH, we have only to paſs the plane AB a little nearer to QR, but ſtill parallel to it. This will diminiſh the ſum of the lines DC, and increaſe the ſum of Position the lines GH. We may do this till the ſums are equal.

In like manner we can do this with reſpect to a plane LM (alſo perpendicular to the paper), perpendicular to the plane AB. The point wanted is ſomewhere in the plane AB, and ſomewhere in the plane LM. Therefore it is ſomewhere in the line in which theſe two planes interſect each other. The line paſſes through the point P of the paper where the two lines AB and LM cut each other. Theſe two lines repreſent planes, but are, in fact, only the interſection of thoſe planes with the plane of the paper. Part of the body muſt be conceived as being above the paper, and part of it behind or below the paper. The plane of the paper therefore divides the body into two parts. It may be ſo ſituated, therefore, that the ſum of all the diſtances from it to the particles lying above it ſhall be equal to the ſum of all the diſtances of thoſe which are below it. Therefore the ſituation of the point P is now determined, namely, at the common interſection of three planes perpendicular to each other. It is evident that this point alone can have the condition required in reſpect to theſe three planes.

But it ſtill remains to be determined whether the ſame condition will hold true for the point thus found, in reſpect to *any other* plane paſſing through it; that is, whether the ſum of all the perpendiculars on one ſide of *this fourth* plane is equal to the ſum of all the perpendiculars on the other ſide. Therefore

Let AGHB (fig. 3.), AXYB, and CDFE, be three planes interſecting each other perpendicularly in the point C; and let CIKL be any other plane, interſecting the firſt in the line CI, and the ſecond in the line CL. Let P be any particle of matter in the body or ſyſtem. Draw PM, PO, PR, perpendicular to the firſt three planes reſpectively, and let PR, when produced, meet the oblique plane in V; draw MN, ON, perpendicular to CB. They will meet in one point N. Then PMNO is a rectangular parallelogram. Alſo draw MQ perpendicular to CE, and therefore parallel to AB, and meeting CI in S. Draw SV; alſo draw ST perpendicular to VP. It is evident that SV is parallel to CL, and that STRQ and STPM are rectangles.

All the perpendiculars, ſuch as PR, on one ſide of the plane CDFE, being equal to all thoſe on the other ſide, they may be conſidered as compenſating each other; the one being conſidered as poſitive or additive quantities, the other are negative or ſubtractive. There is no difference between their ſums, and the ſum of both ſets may be called 0 or nothing. The ſame muſt be affirmed of all the perpendiculars PM, and of all the perpendiculars PO.

Every line, ſuch as RT, or its equal QS, is in a certain invariable ratio to its correſponding QC, or its equal PO. Therefore the poſitive lines RT are compenſated by the negative, and the ſum total is nothing.

Every line, ſuch as TV, is in a certain invariable ratio to its correſponding ST, or its equal PM, and therefore their ſum-total is nothing

Therefore the ſum of all the lines PV is nothing; but each is in an invariable ratio to a correſponding perpendicular from P on the oblique plane CIKL. Therefore the ſum of all the poſitive perpendiculars on this plane is equal to the ſum of all the negative perpendiculars, and the propoſition is demonſtrated, *viz.* that in in every body, or system of bodies, there is a point such, that if a plane be passed through it *in any direction whatever*, the sum of all the perpendiculars on one side of the plane is equal to the sum of all the perpendiculars on the other side.

The point P, thus selected, may, with great propriety, be called the CENTRE OF POSITION of the body or system.

If A and B (fig. 4.) be the centres of position of two bodies, whose quantities of matter (or numbers of equal particles) are a and b, the centre C lies in the straight line joining A and B, and $AC : CB = b : a$, or its distance from the centres of each are inversely as their quantities of matter. For let $\alpha C \beta$ be any plane passing through C. Draw $A\alpha$, $B\beta$, perpendicular to this plane. Then we have $a \times A\alpha = b \times B\beta$, and $A\alpha : B\beta = b : a$, and, by similarity of triangles, $CA : CB = b : a$.

If a third body D, whose quantity of matter is d, be added, the common centre of position E of the three bodies is in the straight line DC, joining the centre D of the third body with the centre C of the other two, and $DE : EC = a + b : d$. For, passing the plane $E\kappa$ through E, and drawing the perpendiculars $D\delta$, $C\kappa$, the sum of the perpendiculars from D is $d \times D\delta$; and the sum of the perpendiculars from A and B is $\overline{a+b} \times C\kappa$, and we have $d \times D\delta = \overline{a+b} \times C\kappa$; and therefore $DE : EC = a + b : d$.

In like manner, if a fourth body be added, the common centre is in the line joining the fourth with the centre of the other three, and its distance from this centre and from the fourth is inversely as the quantities of matter; and so on for any number of bodies.

If all the particles of any system be moving uniformly, in straight lines, in any directions, and with any velocities whatever, the centre of the system is either moving uniformly in a straight line, or is at rest.

For let m be the number of particles in the system. Suppose any particle to move uniformly in any direction. It is evident, from the reasoning in a former paragraph, that the motion of the common centre is the mth part of this motion, and is in the same direction. The same must be said of every particle. Therefore the motion of the centre is the motion which is compounded of the mth part of the motion of each particle. And because each of these was supposed to be uniform and rectilineal, the motion compounded of them all is also uniform and rectilineal; or it may happen that they will so compensate each other that there will be no diagonal, and the common centre will remain at rest.

Cor. 1. If the centres of any number of bodies move uniformly in straight lines, whatever may have been the motions of each particle of each body, by rotation or otherwise, the motion of the common centre will be uniform and rectilineal.

Cor. 2. The quantity of motion of such a system is the sum of the quantities of motion of each body, reduced to the direction of the centre's motion. And it is had by multiplying the quantity of matter in the system by the velocity of the centre.

The velocity of the centre is had by reducing the motion of each particle to the direction of the centre's motion, and then dividing the sum of those reduced motions by the quantity of matter in the system.

By the selection of this point, we render the investigation of the motions and actions of bodies incomparably more simple and easy, freeing our discussions from numberless intricate complications of motion, which would frequently make our progress almost impossible.

POSITION, in arithmetic, called also *False Position*, or *Supposition*, or *Rule of False*, is a rule so called, because it consists in calculating by false numbers supposed or taken at random, according to the process described in any question or problem proposed, as if they were the true numbers, and then from the results, compared with that given in the question, the true numbers are found.

Thus, take or assume any number at pleasure for the number sought, and proceed with it as if it were the true number, that is, perform the same operations with it as, in the question, are described to be performed with the number required: then if the result of those operations be the same with that mentioned or given in the question, the supposed number is the same as the true one that was required; but if it be not, make this proportion, *viz.* as your result is to that in the question, so is your supposed false number to the true one required.

Example. What number is that, to which if we add $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, and $\frac{1}{6}$ of itself, the sum will be 240?

Suppose 99
$$
\begin{array}{rl}
49.5 & = \frac{1}{2} \\
33. & = \frac{1}{3} \\
24.75 & = \frac{1}{4} \\
16.5 & = \frac{1}{6} \\
\hline
222.75 & = \text{result}
\end{array}
$$

Then, as $222.75 : 240 :: 99 : 106.6 =$ Answer.
$$
\begin{array}{rl}
53.\dot{3} & = \frac{1}{2} \\
35.5 & = \frac{1}{3} \\
26.\dot{6} & = \frac{1}{4} \\
17.\dot{7} & = \frac{1}{6} \\
\hline
240. & = \text{proof.}
\end{array}
$$

This is *single* position.

Sometimes it is necessary to make two different suppositions or assumptions, when the same operations must be performed with each as in the single rule. If neither of the supposed numbers solve the question, find the differences between the results and the given number; multiply each of these differences into the other's position; and if the errors in both suppositions be of the same kind, *i. e.* if both suppositions be either less or greater than the given number, divide the differences of the products by the differences of the errors. If the errors be not of the same kind, *i. e.* if the one be greater and the other less than the given number, divide the sum of the products by the sum of the errors. The quotient, in either case, will be the answer.

Example. Three partners, A, B, and C, bought a sugar-work which cost them L. 2000; of which A paid a certain sum unknown; B paid as much as A, and L. 50 over; C paid as much as them both, and L. 25 over: What sum did each pay?

(1.) Suppose A paid L. 500
B —— 550
C —— 1075

2125
2000

125 = error of excess.

(2.) Sup-

Pottery.

(2.) Suppose A paid L.400
B —— 450
125 = excess. C —— 875
———
400 = 2d position. 1725
——— 2000
50000 ———
275 = error of defect.
500 = 1st position.
———
1st error, 125 137500
2d —— 275 50000
——— ———
400)187500
———
Answers. { 468.75 = sum paid by A.
518.75 = ——— B.
1012.5 = ——— C. }
———
2000 . . . = proof.

This is called double position.

POTTERY is an art of very considerable importance; and in addition to what has been said on it in the *Encyclopædia*, the following reflections, by that eminent chemist Vauquelin, will probably be acceptable to many of our readers.

Four things (says he) may occasion difference in the qualities of earthen-ware: 1*st*, The nature or composition of the matter; 2*d*, The mode of preparation; 3*d*, The dimensions given to the vessels; 4*th*, The baking to which they are subjected. By composition of the matter, the author understands the nature and proportions of the elements of which it is formed. These elements, in the greater part of earthen ware, either valuable or common, are silex, argil, lime, and sometimes a little oxide of iron. Hence it is evident that it is not so much by the diversity of the elements that good earthen-ware differs from bad, as by the proportion in which they are united. Silex or quartz makes always two-thirds at least of earthen-ware; argil or pure clay, from a fifth to a third; lime, from 5 to 20 parts in the hundred; and iron from 0 to 12 or 15 parts in the hundred. Silex gives hardness, infusibility, and unalterability; argil makes the paste pliable, and renders it fit to be kneaded, moulded, and turned at pleasure. It possesses at the same time the property of being partially fused by the heat which unites its parts with those of the silex; but it must not be too abundant, as it would render the earthen-ware too fusible and too brittle to be used over the fire.

Hitherto it has not been proved by experience that lime is necessary in the composition of pottery: and if traces of it are constantly found in that substance, it is because it is always mixed with the other earths, from which the washings and other manipulations have not been able to separate it. When this earth, however, does not exceed five or six parts in a hundred, it appears that it is not hurtful to the quality of the pottery; but if more abundant, it renders it too fusible.

The oxide of iron, besides the inconvenience of communicating a red or brown colour, according to the degree of baking, to the vessels in which it forms a part, has the property of rendering them fusible, and even in a greater degree than lime.

As some kinds of pottery are destined to melt very penetrating substances, such as salts, metallic oxides, glass, &c. they require a fine kind of paste, which is obtained only by reducing the earths employed to very minute particles. Others destined for melting metals, and substances not very penetrating, and which must be able to support, without breaking, a sudden transition from great heat to great cold, require for their fabrication a mixture of calcined argil with raw argil. By these means you obtain pottery, the coarse paste of which resembles *breche*, or small grained pudding-stone, and which can endure sudden changes of temperature.

The baking of pottery is also an object of great importance. The heat must be capable of expelling humidity, and agglutinating the parts which enter into the composition of the paste, but not strong enough to produce fusion; which, if too far advanced, gives to pottery a homogenuousness that renders it brittle. The same effect takes place in regard to the fine pottery, because the very minute division given to the earths reduces them nearly to the same state as if this matter had been fused. This is the reason why porcelain strongly baked is more or less brittle, and cannot easily endure alternations of temperature. Hence coarse porcelain, in the composition of which a certain quantity of calcined argil is employed, porcelain retorts, crucibles, tubes, and common pottery, the paste of which is coarse, are much less brittle than dishes and saucers formed of the same substance, ground with more labour.

The general and respective dimensions of the different parts of vessels of earthen-ware have also considerable influence on their capability to stand the fire.

In some cases the glazing or covering, especially when too thick, and of a nature different from the body of the pottery, also renders them liable to break. Thus, in making some kinds of pottery, it is always essential, 1*st*, To follow the best proportion in the principles; 2*d*, To give to the particles of the paste, by grinding, a minuteness suited to the purpose for which it is intended, and to all the parts the same dimensions as far as possible; 3*d*, To carry the baking to the highest degree that the matter can bear without being fused; 4*th*, To apply the glazing in thin layers, the fusibility of which ought to approach as near as possible to that of the matter, in order that it may be more intimately united.

C. Vauquelin, being persuaded that the quality of good pottery depends chiefly on using proper proportions of the earthy matters, thought it might be of importance, to those engaged in this branch of manufacture, to make known the analysis of different natural clays employed for this purpose, and of pottery produced by some of them, in order that, when a new earth is discovered, it may be known by a simple analysis whether it will be proper for the same object, and to what kind of pottery already known it bears the greatest resemblance.

	Hessian Crucibles.	Argil of Drenx.	Porcelain Capsules.	Wedgwood's Pyrometer's.
Silex . . .	69	43.5	61	64.2
Argil* . . .	21.5	33.2	28	25
Lime . . .	1	3.5	6	6
Oxide of iron .	8	1	0.5	0.2
Water . . .	. . .	18	. . .	6.2

Raw

Porcelain, Poules.

Raw kaolin 100 parts.—Silex 74, argil 16·5, lime 2, water 7. A hundred parts of this earth gave eight of alum, after being treated with the fulphuric acid.

Washed kaolin 100 parts.—Silex 55, argil 27, lime 2, iron 0·5, water 14. This kaolin, treated with the fulphuric acid, gave about 45 or 50 *per cent.* of alum.

Petuntzé.—Silex 74, argil 14·5, lime 5·5. lofs 6. A hundred parts of this fubftance, treated with the fulphuric acid, gave feven or eight parts of alum. But this quantity does not equal the lofs fuftained.

Porcelain of retorts.—Silex 64, argil 28·8, lime 4·55, iron 0·50, lofs 2·77. Treated with the fulphuric acid, this porcelain gave no alum.

There is a kind of earthen veffels, called *Alcarrezes*, ufed in Spain for cooling the water intended to be drunk. Thefe veffels confift of 60 parts of calcareous earth, mixed with alumina and a little oxyd of iron, and 36½ of filiceous earth, alfo mixed with alumina and the fame oxide. The quantity of iron may be eftimated at almoft one hundredth part of the whole. This earth is firft kneaded into a tough pafte. being for that purpofe previoufly diluted with water; formed into a cake of about fix inches in thicknefs, and left in that ftate till it begin to crack. It is then kneaded with the feet, the workman gradually adding to it a quantity of fea falt, in the proportion of feven pounds to a hundred and fifty; after which it is applied to the lath, and baked in any kind of furnace ufed by potters. The alcarrezes, however, are only about half as much baked as the better kinds of common earthen ware; and being exceedingly porous, water oozes through them on all fides. Hence the air, which comes in contact with it by making it evaporate, carries off the caloric contained in the water in the veffel, which is thus rendered remarkably cool.

POULES, or FOULQUES, one of the principal nations which inhabit the banks of the Senegal. They poffefs an extent of more than fixty leagues along the river, and exact heavy cuftoms from the Senegal traders with the interior of the country. They are not fo black as the other negroes, but of a copper colour, much inclining to red. It is remarkable, however, that their children who are fent to Senegal, and refide there for fome years, become much blacker. The females are very handfome, and the whites of Senegal generally take care to procure fome of them. But they are of a bad difpofition, and utterly incapable of attachment. When a man has a miftrefs of this nation, he muft watch her conduct very narrowly, and even chaftife her, that fhe may not be guilty of infidelity to him whom fhe honours with her favours. The dread of the baftinado will, in fuch cafe, effect what attention and complaifance can never bring about.

Although the Poules inhabit one of the fineft fpots in Africa, they are neverthelefs a wretched people; they are bafe, cruel, thievifh, and fanatic in the extreme. They are commanded by a chief of their religion, which is a contemptible mixture of Mahometanifm and idolatry. This chief is called the *Almamy*; he is always chofen from among the Tampfirs, who are twelve in number. The Tampfirs are the interpreters of the law, and are the moft learned, or rather the moft fanatical among them. The Almamy has the power of life and death over his fubjects; yet he may be depofed by an affembly of Tampfirs: it is therefore his intereft to keep on good terms with them. The payment of cuftoms is made to the Almamy, and is afterwards diftributed among the Tampfirs; and although a part belongs to the former, he neverthelefs requires a feparate prefent for himfelf.

Printing

PRINTING. (See that article, *Encycl.* and TYPOGRAPHY in this *Supplement.*) We fhall here only defcribe a *PRINTING Prefs*, for the invention of which a patent was granted, in 1790, to Mr William Nicholfon of New North-ftreet, Red Lion Square, London. This machine, with fome flight varieties, is adapted for printing on *paper*, *linen*, *cotton*, *woollen*, and other articles, in a more neat, cheap, and accurate method, the author thinks, than the printing preffes now in ufe.

The invention confifts in three particulars, 1*ft*, The manner of preparing and placing the types, engravings, or carvings, from which the impreffion is to be made; 2*dly*, In applying the ink or colouring matter to types or engravings; and, 3*dly*, In taking off the impreffion.

1*ft*, Mr Nicholfon makes his moulds, punches, and matrices, for cafting letters, in the fame manner, and with the fame materials, as other letter-founders do, excepting that, inftead of leaving a fpace in the mould for the ftem of one letter only, he leaves fpaces for two, three, or more letters, to be caft at one pouring of the metal; and at the lower extremity of each of thofe fpaces (which communicate by a common groove at top) he places a matrix, or piece of copper, with the letter punched upon its face in the ufual way. And moreover, he brings the ftem of his letters to a due form and finifh, not only by rubbing it upon a ftone, and fcraping it when arranged in the finifhing-ftick, but likewife by fcraping it, on one or more fides, in a finifhing-ftick whofe hollowed part is lefs deep at the inner than the outer fide. He calls that fide of the groove which is neareft the face of the difpofed letter, the outer fide; and the purpofe accomplifhed by this method of fcraping is, that of rendering the tail of the letter gradually fmaller the more remote it is, or farther from the face. Such letters may be firmly impofed upon a cylindrical furface, in the fame manner as common letters are impofed upon a flat ftone.

2*dly*, He applies the ink or colouring matter to the types, forms, or plates, by caufing the furface of a cylinder, fmeared or wetted with the colouring matter, to roll over the furfaces of the faid forms or plates, or by caufing the forms or plates apply themfelves fucceffively to the furface of the cylinder. The furface of this colouring cylinder is covered with leather, or with woollen, linen, or cotton-cloth. When the colour to be ufed is thin, as in calico-printing, and in almoft every cafe, the covering is fupported by a firm elaftic ftuffing, confifting of hair, or wool, or woollen cloth wrapped one or more folds round the cylinder. When the covering confifts of woollen cloth, the ftuffing muft be defended by leather, or oilfkin, to prevent its imbibing too much colour. and by that means lofing its elafticity. It is abfolutely neceffary that the colouring matter be evenly diftributed over the furface of the cylinder; and for this purpofe, when the colour is thick and ftiff, as in letter-prefs printing, he applies two, three, or more fmall cylinders, called diftributing-rollers, longitudinally againft the colouring cylinders, fo that they may be turned by the motion of the latter; and the effect of this application is, that every lump or mafs of colour

which

Printing. which may be redundant, or irregularly placed upon the face of the colouring cylinder, will be pressed, spread, and partly taken up, and carried by the small rollers to the other parts of the colouring cylinder; so that this last will very speedily acquire and preserve an even face of colour. But if the colouring matter be thinner, he does not apply more than one or two of these distributing-rollers; and, if it be very thin, he applies an even blunt edge of metal, or wood, or a straight brush, or both of these last, against the colouring cylinder, for the purpose of rendering its colour uniform. When he applies colour to an engraved plate, or cylinder, or through the interstices of a perforated pattern, as in the manufacturing of some kinds of paper-hangings, he uses a cylinder entirely covered with hair or bristles in the manner of a brush.

3dly, He performs all his impressions, even in letter-press printing, by the action of a cylinder or cylindrical surface. The construction of this machine, and the manner of using it, will be intelligible to every reader who shall attentively consider Plate XL: where fig. 1. represents a printing-press, more especially applicable to the printing of books. A and E are two cylinders, running or turning in a strong frame of wood, or metal, or both. The cylinder A is faced with woollen cloth, and is capable of being pressed with more or less force upon HI, by means of the lever M. HI is a long table, which is capable of moving endwise, backwards and forwards, upon the rollers E and K. The roller A acts upon this table by means of a cog-wheel, or by straps, so as to draw it backwards and forwards by the motion of its handle L. The table is kept in the same line by grooves on its sides, which contain the cylinder A. D is a chase, containing letter set up and imposed. B is a box, containing a colouring-roller, with its distributing-rollers CC; it is supported by the arm N. O is a cylinder faced with leather, and lying across an ink-block; this cylinder is fixed by the middle to a bended lever moveable on the joint Q.

The action. When D, or the letter, is drawn beneath the cylinder B, it receives ink; and when it has passed into the position R, a workman places or turns down a tympan with paper upon it (this tympan differs in no respect from the usual one, except that its hinge opens sidewise); it then proceeds to pass under the cylinder A, which presses it successively through its whole surface. On the other side, at S, the workman takes off the paper, and leaves the tympan up. This motion causes the cylinder B to revolve continually, and consequently renders its inked surface very uniform, by the action of its distributing-rollers CC; and, when the table has passed to its extreme distance in the direction now spoken of, the arm G touches the lever P, and raises the cylinder O off the ink-block, by which means it dabs against one of the distributing-rollers, and gives it a small quantity of ink. The returning motion of the table carries the letter again under the roller B, which again inks it, and the process of printing another sheet goes on as before.

Fig. 2. is another printing-press. In this, B is the inking-roller; A is a cylinder, having the letter imposed upon its surface; and E is a cylinder, having its uniform surface covered with woollen cloth: these three cylinders are connected, either by cogs or straps at the edges of each. The machine is uniformly turned in one direction by the handle L. The workman applies a sheet of paper to the surface of E, where it is retained, either by points in the usual manner, or by the apparatus to be described in treating of fig. 4. The paper passes between E and A, and receives an impression; after which the workman takes it off, and applies another sheet; and in the mean time the letter on the surface of A passes round against the surface of B, and receives ink during the rotation of B. The distributing-rollers CC do their office as in the machine fig. 1.; and once in every revolution the tail F, affixed to B, raises the inking-piece G, so as to cause it to touch one of the distributing-rollers, and supply it with ink. In this way therefore the repeated printing of sheet after sheet goes on. Printing.

Fig. 3. is a printing-press, more particularly adapted to print cottons, silks, paper-hangings, or other articles which run of a considerable length. A is a cylinder covered with woollen cloth, or other soft substance. The web or piece of cotton, or other goods, is passed round this cylinder, from the carrying-roller F to the receiving-rollers GH; which are connected by a piece of linen, woollen, or hair-cloth, in the manner of a jack-towel sewed round them; the rotation of this towel carries away the printed stuff or goods, and deposits them at I. KL is a moveable box, containing three rollers, which move against each other in rotation. The lowest roller C revolves in a mass of colour, contained in a trough or vessel in the bottom part of the box KL; the surface of this colour is represented by the line MN. The next roller B is stuffed and covered as described in section 2. The pressure of B against C prevents the cylinder B from receiving too much colour. D is a cut or carved cylinder, which receives colour, during the rotation, from the roller B, and impresses it upon the web as it passes round the cylinder A; in this way the constant and effectual action of the machine is sufficiently obvious. It must be observed, that the cylinders ADB and G are connected together by cog-wheels, straps, or other well-known equivalent contrivances; so that the handle P drives the whole, without their necessarily depending on any adhesion or friction at their surfaces. The pressure of B against D is governed by an adjustment of the axis of D, whose sockets are capable of a small motion; and the pressure of D against A is governed by the position of the whole box KL. When it is required to print more than one colour upon a piece, Mr Nicholson causes it to pass two or more times through the machine; or, in those cases where the materials are liable to change their dimensions, he applies, at one and the same time, two or more such boxes as KL, with their respective cylinders, so that the pattern cylinder of each may make its impression upon the web or material to be printed on.

Fig. 4. is a printing-press, chiefly of use for books and papers. 1, 2, 3, 4, represents a long table, with ledges on each side; so that the two cylinders A and B can run backwards and forwards without any side shake. In one of these ledges is placed a strip or plate of metal cut into teeth, which lock into correspondent teeth in each cylinder; by which means the two cylinders roll along, without the possibility of changing the relative positions of their surfaces at any determinate part of the table. This may also be effected by straps, and

Printing. and may indeed be accomplished, with tolerable accuracy, by the mere rolling of the cylinders on the smooth or flat ledges without any provision. A is the printing-cylinder, covered with woollen cloth, and B is the inking cylinder, with its distributing rollers. The table may be divided into four compartments, marked with a thicker bounding line than the rest, and numbered 1, 2, 3, 4. At 1 is placed a sheet of paper; at 2 is the form or chase, containing letter set and imposed; at 3 is an apparatus for receiving the printed sheet; and 4 is employed in no other use than as a place of standing for the carriage E, after it has passed through one operation, and when it takes ink at F. Its action is as follows: the carriage is thrust forward by the workman, and as the roller A passes over the space numbered 1, it takes up the sheet of paper previously laid there, while the roller B runs over the form and inks the letter. The sheet of paper, being wrapped round the cylinder A, is pressed against the form as that cylinder proceeds, and consequently it receives an impression. When A arrives at the space numbered 3, it lets go the sheet of paper, while the prominent part of the carriage G strikes the lever P, and raises the inking-piece, which applies itself against one of the distributing rollers. In this manner therefore the cylinder A returns empty, and the cylinder B inked, and in the mean time the workman places another sheet of paper ready in the space numbered 1. Thus it is that the operation proceeds in the printing of one sheet after another.

The preceding description is not incumbered with an account of the apparatus by which the paper is taken up and laid down. This may be done in several ways: Fig. 9. and 10. represent one of the methods. DE is a lever, moving on the centre pin C, and having its end D pressed upwards by the action of the spring G. The shoulder which contains the pin C is fixed in another piece F, which is inserted in a groove in the surface of the cylinder A (fig. 4.), so that it is capable of moving in and out, in a direction parallel to the axis of that cylinder. As that cylinder proceeds, it meets a pin in the table; which (letter P, fig. 9.) acting on the inclined plane at the other end of the lever, throws the whole inwards, in the position represented in fig. 10.; in which case the extremity D shoots inwards, and applies itself against the side of the cylinder.

In fig. 11. is a representation of part of the table; the dotted square represents a sheet of paper, and the four small shaded squares denote holes in the board, with pins standing beside them. When the lever DE (fig. 10.) shoots forward, it is situated in one of these holes, and advances under the edge of the paper, which consequently it presses and retains against the cylinder with its extremity D. Nothing more remains to be said respecting the taking up, but that the cylinder is provided with two pair of these clasps or levers, which are so fixed as to correspond with the four holes represented in fig. 11. It will be easy to understand how the paper is deposited in the compartment n° 3. (fig. 4.). A pin P (fig. 10.) rising out of the platform or table, acts against a pin E, projecting sidewise out of the lever, and must of course draw the slider and its lever to the original position; the paper consequently will be let go, and its disengagement is rendered certain by an apparatus fixed in the compartment numbered 3. (fig. 4.) of exactly the same kind as that upon the cylinder, and which, by the action of a pin duly placed in the surface of the cylinder A, takes the paper from the cylinder in precisely the same manner as that cylinder originally took it up in the compartment numbered 1 (fig 4.)

Figs. 5, 6, and 7, represent a simpler apparatus for accomplishing the same purpose. If A a B b (fig. 7.) be supposed to represent a thick plate of metal of a circular form, with two pins, A and B, proceeding sidewise or perpendicularly out of its plane, and diametrically opposite to each other, and G another pin proceeding in the direction of that plane, then it is obvious that any force applied to the pin A, so as to press it into the position a (by turning the plate on its axis or centre X), will at the same time cause the pin G to acquire the position g; and, on the other hand, when B is at b, or the dotted representation of the side-pin, if any pressure be applied to restore its original position at B, the pin g will return back to G. Now the figures 5 and 6 exhibit an apparatus of this kind, applied to the cylinder A; and that cylinder, by rolling over the pins P and p, properly fixed in the table to re-act upon the apparatus, will cause its prominent part G either to apply to the cylinder and clasp the paper, or to rise up and let it go. The compartment numbered 3 (fig. 4.) must of course have an apparatus of the same kind to be acted upon by pins from A, in order that it may take the paper from that cylinder.

There is one other circumstance belonging to this machine which remains to be explained. When the carriage E (fig. 4.) goes out in the direction of the numbers 1, 2, 3, 4, both rollers, A and B, press the form of letter in their passage; but in their return back again the roller A, having no paper upon it, would itself become soiled, by taking a faint impression from the letter, if it were not prevented from touching it: the manner of effecting this may be understood from fig. 12. The apparatus there represented is fixed upon the outside of the carriage E, near the lower corner, in the vicinity of the roller A; the whole of this projects sidewise beyond the ledge of the table, except the small truck or wheel B. The irregularly-triangular piece, which is shaded by the stroke of the pen, carries this wheel, and also a catch moveable on the axis or pin E. The whole piece is moveable on the pin A, which connects it to the carriage. CD, or the part which is shaded by dotting, is a detent, which serves to hold the piece down in a certain position. It may be observed, that both the detent and the triangular piece are furnished each with a claw, which holds in one direction, but trips or yields in the other, like the jacks of a harpsichord, or resembling certain pieces used in clock and watch making, as is clearly represented in the figure. These claws overhang the side of the table, and their effect is as follows: There is a pin C (fig. 4) between the compartments of the table numbered 2 and 3, but which is marked F in fig. 12. where GH represents the table. In the outward run of the carriage these claws strike that pin, but with no other effect than that they yield for an instant, and as instantly resume their original position by the action of their respective slender back-springs. When the carriage returns, the claw of the detent indeed strikes the pin, but with as little effect as before, because its derangement is instantly removed by the action of the back spring of the detent itself;

 but,

but, when the claw of the triangular piece takes the pin, the whole piece is made to revolve on its axis or pin A, the wheel B is forced down, fo as to lift that end of the carriage, and the detent, catching on the piece at C, prevents the former pofition from being recovered. The confequence of this is, that the carriage runs upon the truck B (and its correfpondent truck on the oppofite fide) inftead of the cylinder A, which is too much raifed to take the letter, and foil itfelf; but as foon as the end of the carriage has paffed clear of the letter, another pin R (fig. 4.) takes the claw of the detent, and draws it off the triangular piece; at which inftant the cylinder A fubfides to its ufual place, and performs its functions as before. This laft pin R does not affect the claw of the triangular piece, becaufe it is placed too low; and the claw of the detent is made the longeft, on purpofe that it may ftrike this pin.

Fig. 8. reprefents an inftrument for printing floor-cloths, paper-hangings, and the like, with ftiff paint and a brufh. D is a copper or metallic cylinder fixed in a frame A, like a garden roller; its carved part is thin, and is cut through in various places, according to the defired pattern. A ftrong axis paffes through the cylinder, and its extremities are firmly attached to the frame A. To this axis is fixed a veffel or box of the fame kind, and anfwering the fame purpofe as the box KL in fig. 3. It carries a cylinder P, which revolves in the colour; another cylinder E, which revolves in contact with P; and a third cylinder B, whofe exterior furface is covered with hair, after the manner of a brufh, and revolves in contact with E. This cylinder B is adjufted by its axis, in fuch a manner that its brufh-part fweeps in the perforated parts of the metallic cylinder D. The circle C reprefents a cog-wheel, fixed concentric to the cylinder D, and revolving with it; this wheel takes another wheel concentric to, and fixed to, B; hence the action is as follows: When the metallic cylinder is wheeled or rolled along any furface, its cog-wheel C drives the brufh B in the contrary direction; and this brufh-cylinder, being connected by cogs or otherwife with E and P, caufes thofe alfo to revolve and fupply it with colour. As the fucceffive openings of the cylinder, D, therefore, come in contact with the ground, the feveral parts of the brufh will traverfe the uncovered part of that ground, and paint the pattern upon it. The wheel G, being kept lightly on the ground, ferves to determine the line of contact, that it fhall be the part oppofite to B, and no other.

PRINTS (fee *Encycl.*) are valuable on many accounts; but they are liable to be foiled by fmoke, vapour, and the excrements of infects. Different methods have, of courfe, been practifed to clean them. Some have propofed fimple wafhing with clear water, or a ley made of the afhes of reeds, and then expofing the prints to the dew. Others have cleaned prints with *aqua fortis* (fulphuric acid); but both thefe methods are attended with a degree of rifk at leaft equal to their advantages. The following method of cleaning prints is recommended in the fecond volume of Nicholfon's Journal of Natural Philofophy, &c. as at once fafe and efficacious:

"Provide a certain quantity of the common muriatic acid, for example three ounces, in a glafs bottle, with a ground ftopper, of fuch a capacity that it may be only half full. Half an ounce of minium muft then be added; immediately after which the ftopper is to be put in, and the bottle fet in a cold and dark place. The heat, which foon becomes perceptible, fhews the beginning of the new combination. The minium abandons the greateft part of its oxygen with which the fluid remains impregnated, at the fame time that it acquires a fine golden yell w, and emits the deteftable fmell of oxygenated muriatic acid. It contains a fmall portion of muriat of lead; but this is not at all noxious in the fubfequent procefs. It is alfo neceffary to be obferved, that the bottle muft be ftrong, and the ftopper not too firmly fixed, otherwife the active elaftic vapour might burft it. The method of ufing this prepared acid is as follows:

"Provide a fufficiently large plate of glafs, upon which one or more prints may be feparately fpread out. Near the edges let there be raifed a border of foft white wax half an inch high, adhering well to the glafs and flat at top. In this kind of trough the print is to be placed in a bath of frefh urine, or water containing a fmall quantity of ox-gall, and kept in this fituation for three or four hours. The fluid is then to be decanted off, and pure warm water poured on; which muft be changed every three or four hours until it paffes limpid and clear. The impurities are fometimes of a refinous nature, and refift the action of pure water. When this is the cafe, the wafhed print muft be left to dry, and alcohol is then to be poured on and left for a time. After the print is thus cleaned, and all the moifture drained off, the muriatic acid prepared with minium is to be poured on in fufficient quantity to cover the print; immediately after which another plate of glafs is to be laid in contact with the rim of wax, in order to prevent the inconvenient exhalation of the oxygenated acid. In this fituation the yelloweft print will be feen to recover its original whitenefs in a very fhort time. One or two hours are fufficient to produce the defired effect; but the print will receive no injury if it be left in the acid for a whole night. Nothing more is neceffary to complete the work than to decant off the remaining acid, and wafh away every trace of acidity by repeated affufions of pure water. The print being then left to dry (in the fun if poffible) will be found white, clear, firm, and in no refpect damaged either in the texture of the paper or the tone and appearance of the impreffion."

The judicious editor of the Journal fubjoins the following note, to which collectors of prints will do well to pay attention: "As I have not repeated this procefs, I cannot eftimate how far the prefence of the lead may weaken the corrofive action of the acid on the paper; but I fhould be difpofed to recommend a previous dilution of the acid with water. Whoever ufes this procefs will of courfe make himfelf mafter of the proportion of water required to dilute the acid, by making his firft trials with an old print of no value."

PRISM, in geometry, is a body or a folid, whofe two ends are any plane figures which are parallel, equal, and fimilar; and its fides, connecting thofe ends, are parallelograms. The definition of this figure in the *Encyclopædia* we muft, in candour, acknowledge to be unaccountably indiftinct, if not unintelligible.

PRISMOID, is a folid or body, fomewhat refembling a prifm, but that its ends are any diffimilar parallel plane figures of the fame number of fides; the up-

Fig. 1.

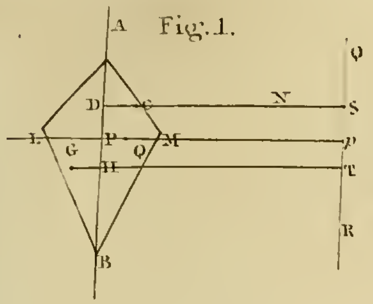


Fig. 2.

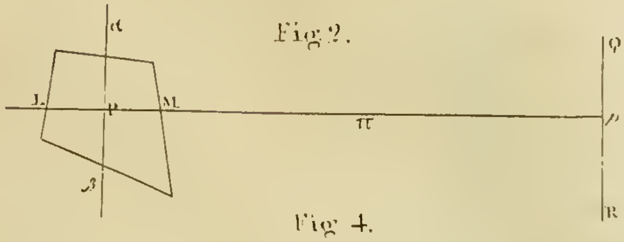


Fig. 3.

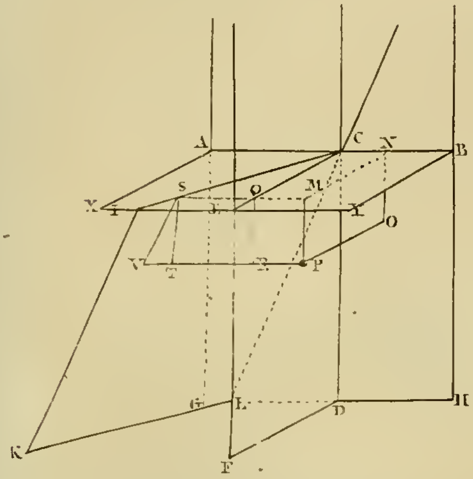
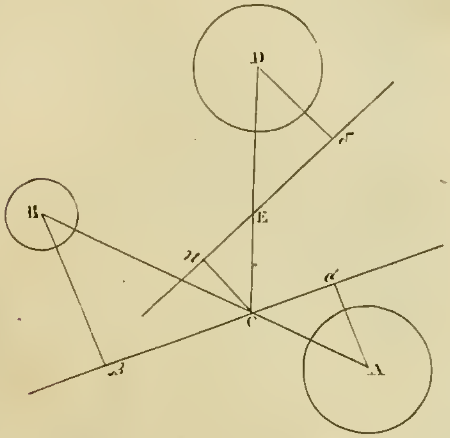
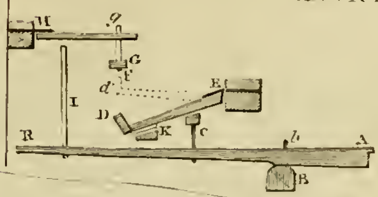


Fig. 4.



KEY &c. of MASON'S PIANO FORTE.



PRINTING PRESS

Fig. 1.

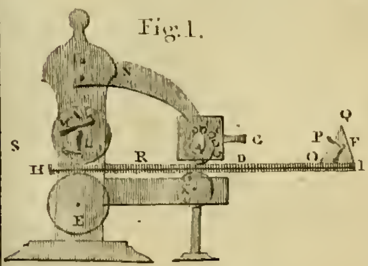


Fig. 2.

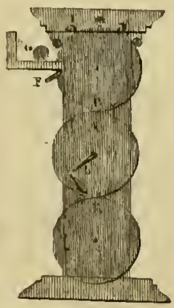


Fig. 3.

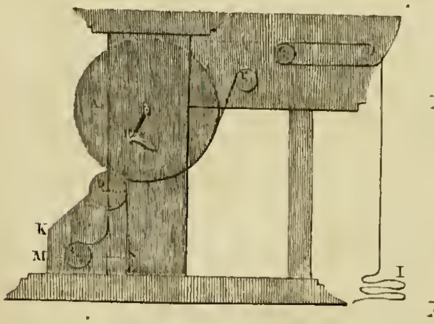


Fig. 9.

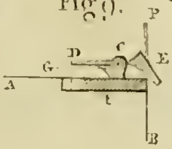


Fig. 5.

Fig. 10.

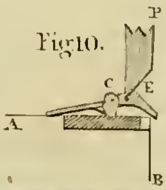


Fig. 6.

Fig. 8.

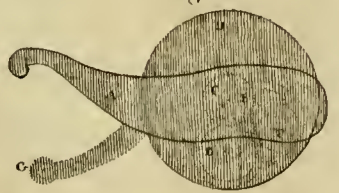


Fig. 4.

Fig. 7.

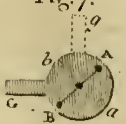


Fig. 11.

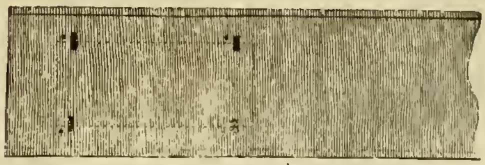
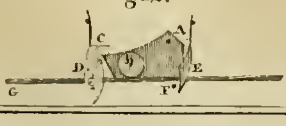
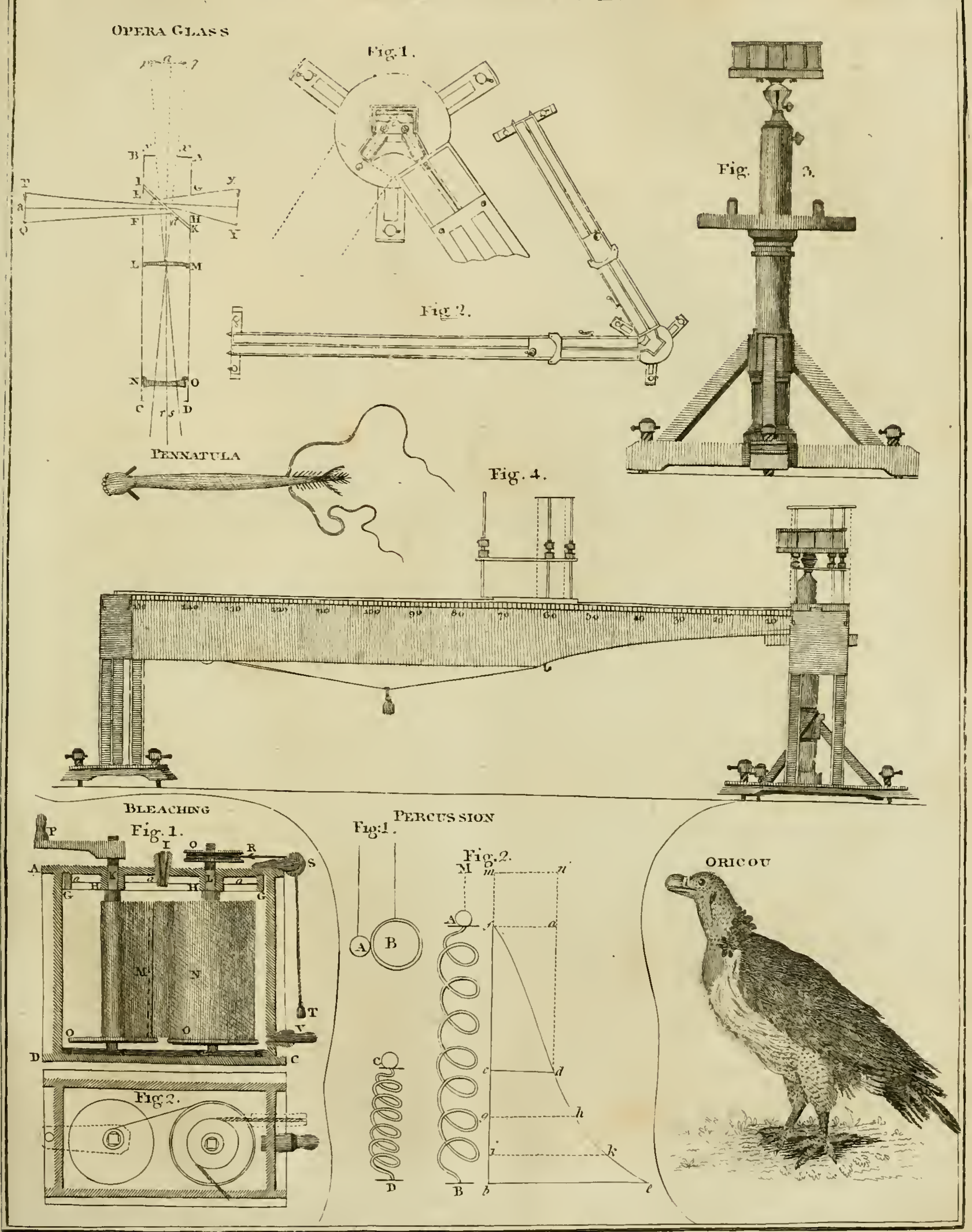


Fig. 12.



PHOTOMETER PLATE XLI.



right ſides being trapezoids.—If the ends of the priſmoid be bounded by diſſimilar curves, it is ſometimes called a *cylindroid*.

PRISON is ſaid, in the *Encyclopædia*, to be only a place of ſafe cuſtody, not a place of puniſhment. Such was, no doubt, the original intention of Engliſh priſons; but now temporary confinement is, in England as well as elſewhere, inflicted as a puniſhment for certain crimes. Perhaps it would be expedient to ſubſtitute this puniſhment more frequently than is yet done in Great Britain, for tranſportation and death; proportioning the length of the confinement, as well as its cloſeneſs, to the heinouſneſs of the crime. In no country, we believe, is this more accurately done, or to better purpoſe, than in Pennſylvania; and ſurely in no country has impriſonment been more abuſed than in Venice under the old government.

By the laws of Pennſylvania, puniſhment by impriſonment is impoſed, not only as an expiation of paſt offences, and an example to the guilty part of ſociety, but alſo for another important purpoſe—the reformation of the criminal's morals. The regulations of the gaol are calculated to promote this effect as ſoon as poſſible; ſo that the building deſerves the name of a *penitentiary houſe* more than that of a *gaol* (ſee PHILADELPHIA, *Encycl*). As ſoon as a criminal is committed to the priſon, he is made to waſh; his hair is ſhorn; and, if not decently clothed, he is furniſhed with clean apparel. He is then thrown into a ſolitary cell, about nine feet long and four wide, where he remains debarred from the ſight of every living being except his gaoler, whoſe duty is to attend to his bare neceſſities, but who is forbidden on any account to hold converſation with him. If a priſoner be at all refractory, or if the offence for which he is committed be of a very atrocious nature, he is then confined to a cell ſecluded even from the light of heaven. The treatment of each priſoner, during his confinement, is varied according to his crime and his ſubſequent repentance. Solitary confinement in a dark cell is looked upon as the ſevereſt uſage; next, ſolitary confinement in a cell with the admiſſion of light; next, ſolitary confinement in a cell, where the priſoner is allowed to do ſome ſort of work; and, laſtly, labour in company with others. The longeſt period of confinement is for a rape, which is not to be leſs than ten years, nor more than twenty-one; for high treaſon it is not to exceed twelve, nor fall ſhort of ſix years.

The priſoners are obliged to bathe twice every week, proper conveniences for that purpoſe being provided within the walls of the priſon, and alſo to change their linen, with which they are regularly ſupplied. Thoſe in ſolitary confinement are kept upon bread and water; but thoſe who labour are allowed broth, porridge, puddings, and the like. Meat is diſpenſed only in ſmall quantities, twice in the week; and on no pretence whatever is any other beverage than water ſuffered to be brought into the priſon. Thoſe who labour are employed in the trade to which they have been accuſtomed; and for thoſe acquainted with no particular trade, ſome kind of work is deviſed which they can perform. One room is ſet apart for ſhoemakers, another for tailors, a third for carpenters, and ſo on. In the yards are ſtone-cutters, ſmiths, nailers, &c. In a word, this priſon has all the advantages of the raſping houſe of Amſterdam, without any of its enormous defects. See *Correction-Houſe* in this *Suppl*.

The priſon of Venice is of a very different deſcription, and is worthy of notice here only as a curioſity in the annals of tyranny, which has, we hope, paſſed away with the government which contrived it. Dr Moſeley, in conſequence of his being an Engliſh phyſician (a character then highly reſpected in Venice), was permitted, on the 16th of September 1787, to viſit the common priſon, but was abſolutely refuſed admittance into the *Sotto Piombi*, where the ſtate priſoners were kept. As the Doctor believes that no foreigner beſides himſelf ever witneſſed the ſcenes, even in the common priſon, which he relates, we ſhall give his relation in his own words.

"I was conducted (ſays he) through the priſon by one of its inferior dependants. We had a torch with us. We crept along narrow paſſages as dark as pitch. In ſome of them two people could ſcarcely paſs each other. The cells are made of maſſy marble; the architecture of the celebrated Sanſovini.

"The cells are not only dark, and black as ink, but being ſurrounded and confined with huge walls, the ſmalleſt breath of air can ſcarcely find circulation in them. They are about nine feet ſquare on the floor, arched at the top, and between ſix and ſeven feet high in the higheſt part. There is to each cell a round hole of eight inches diameter, through which the priſoner's daily allowance of twelve ounces of bread and a pot of water is delivered. There is a ſmall iron door to the cell. The furniture of the cell is a little ſtraw and a ſmall tub; nothing elſe. The ſtraw is renewed and the tub emptied through the iron door occaſionally.

"The diet is ingeniouſly contrived for the perduration of puniſhment. Animal food, or a cordial nutritious regimen, in ſuch a ſituation, would bring on diſeaſe, and defeat the end of this Venetian juſtice. Neither can the ſoul, if ſo inclined, ſteal away, wrapt up in ſlumbering deluſion, or ſink to reſt, from the admonition of her ſad exiſtence, by the gaoler's daily return.

"I ſaw one man who had been in a cell thirty years; two who had been twelve years; and ſeveral who had been eight and nine years in their reſpective cells.

"By my taper's light I could diſcover the priſoners horrid countenances. They were all naked. The man who had been there thirty years, in face and body was covered with long hair. He had loſt the arrangement of words and order of language. When I ſpoke to him, he made an unintelligible noiſe, and expreſſed fear and ſurpriſe; and, like ſome wild animals in deſerts, which have ſuffered by the treachery of the human race, or have an inſtinctive abhorrence of it, he would have fled like lightning from me if he could.

"One whoſe faculties was not ſo obliterated; who ſtill recollected the difference between day and night; whoſe eyes and ears, though long cloſed with a ſilent blank, ſtill languiſhed to perform their natural functions—implored, in the moſt piercing manner, that I would prevail on the gaoler to murder him, or to give him ſome inſtrument to deſtroy himſelf. I told him I had no power to ſerve him in this requeſt. He then entreated I would uſe my endeavours with the inquiſitors to get him hanged, or drowned in the Canal' Orfano..

fano. But even in this I could not ferve him: death was a favour I had not intereft enough to procure for him.

"This kindnefs of death, however, was, during my ftay in Venice, granted to one man, who had been 'from the cheerful ways of man cut off' thirteen years.

"Before he left his dungeon I had fome converfation with him; this was fix days previous to his execution. His tranfport at the profpect of death was furprifing. He longed for the happy moment. No faint ever exhibited more fervour in anticipating the joys of a future ftate, than this man did at the thoughts of being releafed from life, during the four days mockery of his trial.

"It is in the Canal' Orfano where veffels from Turkey and the Levant perform quarantine. This place is the watery grave of many who have committed political or perfonal offences againft the ftate or fenate, and of many who have committed no offences at all. They are carried out of the city in the middle of the night, tied up in a fack with a large ftone faftened to it, and thrown into the water. Fifhermen are prohibited, on forfeiture of their lives, againft fifhing in this diftrict. The pretence is the plague. This is the fecret hiftory of people being loft in Venice.

"The government, with age, grew feeble; was afraid of the difcuffion of legal procefs and of public executions; and navigated this rotten Bucentaur of the Adriatic by fpies, prifons, affaffination, and the Canal' Orfano."

This is indeed a frightful narrative, and, we doubt not, true as well as frightful; but when, from the ftate of the Venetian prifons, the author infinuates that Howard was not actuated by genuine benevolence, and infers, or wifhes his reader to infer, that the propofal of that celebrated philanthropift for fubftituting folitary confinement, in many cafes, for capital punifhment, muft have refulted from his not taking into confideration the *mind* of the criminal—the infinuation, to fay the leaft of it, is ungenerous, and the conclufion is at war with the premifes. That there was fomething romantic and fuperfluous in Howard's wanderings, we readily admit; but it feems impoffible to doubt of the reality of his benevolence; and though the horrid prifon of Venice, into which, as the Doctor affures us, Mr Howard never entered, was calculated to injure the body without improving the mind of the criminal, it does not follow but that folitary confinement, under fuch regulations as at Philadelphia, is the beft means that have yet been thought of for obtaining the object neareft Howard's heart, the reformation of the morals of the criminal.

PROCYON, in aftronomy, a fixed ftar of the fecond magnitude, in Canis Minor, or the little Dog.

PROSTHAPHERESIS, in aftronomy, the difference between the true and mean motion, or between the true and mean place, of a planet, or between the true and equated anomaly; called alfo *equation of the orbit*, or *equation of the centre*, or fimply the *equation*; and it is equal to the angle formed at the planet, and fubtended by the eccentricity of its orbit.

PROTRACTING, or Protraction, in furveying, the act of plotting or laying down the dimenfions taken in the field, by means of a protractor, &c. Protracting makes one part of furveying.

Protracting-Pin, a fine pointed pin or needle, fitted into a handle, ufed to prick off degrees and minutes from the limb of the protractor

PRUNING. Under this title *(Encycl.)* it is obferved, that when large branches of trees bearing ftone-fruit are taken off, the trees are fubject to gum and decay. For this a remedy has been invented by *Thomas Skip Dyot Bucknall*, Efq; of Conduit-ftreet, which, notwithftanding many objections made to it at firft, experience has proved to be fuccefsful, and for the difcovery of which the Society for the Encouragement of Arts, &c. voted the filver medal to the difcoverer. It is as follows:

Cut every branch which fhould be taken away clofe to the place of its feparation from the trunk; fmooth it well with a knife; and then with a painter's brufh fmear the wound over with what Mr Bucknall calls *medicated tar*. This medicated tar is compofed of one quarter of an ounce of corrofive fublimate, reduced to fine powder by beating with a wooden hammer, and then put into a three pint earthen pipkin, with about a glafs full of gin or other fpirit, ftirred well together, and the fublimate thus diffolved. The pipkin is then filled by degrees with vegetable or common tar, and conftantly ftirred, till the mixture be blended together as intimately as poffible; and this quantity will at any time be fufficient for two hundred trees. To prevent danger, let the corrofive fublimate be mixed with the tar as quickly as poffible after it is purchafed; for, being of a very poifonous nature to all animals, it fhould not be fuffered to lie about a houfe, for fear of mifchief to fome part of the family.

By the application of this compofition, Mr Bucknall can, without the fmalleft danger, ufe the pruning hook on all kinds of trees much more freely than we have recommended its ufe in the article referred to. "I give no attention (fays he) to fruit branches, and wood-branches; but beg, once for all, that no branch fhall ever be fhortened, unlefs for the figure of the tree, and then conftantly taken off clofe to the feparation, by which means the wound foon heals. The more the range of the branches fhoots circularly, a little inclining upwards, the more equally will the fap be diftributed, and the better will the tree bear; for, from that circumftance, the fap is more evenly impelled to every part. Do not let the ranges of branches be too near each other; for remember all the fruit and the leaves fhould have their full fhare of the fun; and where it fuits let the middle of the tree be free from wood, fo that no branch fhall ever crofs another, but all the extreme ends point outwards."

PULO, the name of feveral iflands of Afia, in the Indian Ocean; the principal of which alone, according to Dr Brookes, is inhabited. This is the ifland

Pulo-Condore, which, being vifited by Lord Macartney as he failed to China, is thus defcribed by Sir George Staunton. "It has the advantage of convenient anchoring places in either monfoon. The fquadron accordingly ftopped on the 17th of May, in a fpacious bay on the eaftern fide of the ifland; and came to anchor at the entrance of its fouthern extremity, as the water fhoaled there to five fathoms and a half occafioned by a bank which ftretches acrofs two-thirds of the entrance. It was found afterwards, that beyond the bank there is a fafe paffage to the inner part of the bay,

bay, the north of which is ſheltered by a ſmall iſland lying to the eaſtward. The whole of the bay is formed by four ſmall iſlands, which approach ſo nearly to each other, as to appear, from ſeveral points, to join. They all ſeem to be the rude fragments of primitive mountains, ſeparated from the great continent in the lapſe of time. The principal iſland is eleven or twelve miles in length, and about three in breadth. It is in the form of a creſcent, and conſiſts of a ridge of peaked hills. Its latitude, as calculated from a meridional obſervation, is 8° 40′ north from the equator; and its longitude, according to a good chronometer, is 105° 55′ eaſt from Greenwich.

"The Engliſh had a ſettlement on Condore until the beginning of the preſent century, when ſome Malay ſoldiers in their pay, in reſentment for ſome unjuſtifiable treatment, murdered their ſuperiors, with the exception of a very few who eſcaped off the iſland, where no Europeans have ſince reſided. At the bottom of the bay was a village ſituated cloſe to a fine ſandy beach, with a long range of cocoa-nut trees before it, and it was defended from the north eaſt ſea by a reef of coral rocks, within which was good anchorage for ſmall veſſels, and an eaſy landing for boats. A party went on ſhore from Lord Macartney's ſquadron, with the precaution, however, of being armed, as large canoes were eſpied within the reef, which might have been Malay pirates. Several of the inhabitants came to the beach, and with the appearance of much urbanity of manners welcomed them on ſhore, and conducted them to the houſe of their chief. It was a neat bamboo cabin, larger than the reſt. The floor was elevated a few feet above the ground, and ſtrewed with mats, on which were aſſembled as many men as the place could hold. It was apparently on the occaſion of ſome feſtival, or pleaſurable meeting. There was in one of the apartments an altar decorated with images, and the partitions hung with figures of monſtrous deities; but the countenances and deportment of the people conveyed no idea of religious awe, and no perſon was ſeen in the poſture of prayer or adoration. A few ſpears ſtood againſt the wall with their points downwards, together with ſome matchlocks and a ſwivel gun. The dreſs of thoſe people was compoſed chiefly of blue cotton worn looſely about them; and their flat faces and little eyes denoted a Chineſe origin or relation. Several long ſlips of paper, hanging from the ceiling, were covered with columns of Chineſe writing. One of the miſſionaries, who was of the party, could not, however, in any degree, underſtand their converſation; but when the words were written, they inſtantly became intelligible to him. Though their colloquial language was altogether different from what is ſpoken in China, yet the characters were all Chineſe; and the fact was clearly aſcertained on this occaſion, that thoſe characters have an equal advantage with Arabic numbers, of which the figures convey the ſame meaning wherever known; whereas the letters of other languages denote not things but elementary ſounds, which combined variouſly together, form words, or more complicated ſounds, conveying different ideas in different languages, though the form of their alphabet be the ſame.

"The inhabitants of Pulo Condore were, it ſeems, Cochin-Chineſe, with their deſcendants, who fled from their own country, in conſequence of their attachment to one of its ſovereigns, dethroned by ſeveral of his own ſubjects. It was propoſed to purchaſe proviſions here; and the people promiſed to have the ſpecified quantity ready, if poſſible, the next day, when it was intended, if the weather ſhould be favourable, to land the invalids. The next morning was fair in the beginning; and a party of pleaſure was made from the Hindoſtan to a ſmall iſland cloſe to Pulo Condore. They were ſcarcely arrived upon it when the weather began to lower; and the boat ſet off on its return, in order to reach the ſhip before the impending ſtorm ſhould begin.

"With difficulty it reached the ſhip; and as ſoon as the weather became fair, meſſengers were diſpatched on ſhore to receive and pay for the proviſions promiſed. When they arrived at the village, they were aſtoniſhed to find it abandoned. The houſes were left open, and none of the effects, except ſome arms, that had on the firſt viſit been perceived within them, or even of the poultry feeding about the doors, were taken away. In the principal cabin a paper was found, in the Chineſe language, of which the literal tranſlation purported, as nearly as it could be made, 'that the people of the iſland were few in number, and very poor, yet honeſt, and incapable of doing miſchief; but felt much terror at the arrival of ſuch great ſhips and powerful perſons, eſpecially as not being able to ſatisfy their wants in regard to the quantity of cattle and other proviſions, of which the poor inhabitants of Pulo Condore had ſcarcely any to ſupply, and conſequently could not give the expected ſatiſfaction. They therefore, through dread and apprehenſion, reſolved to fly to preſerve their lives. That they ſupplicate the great people to have pity on them; that they left all they had behind them, and only requeſted that their cabins might not be burnt; and conclude by proſtrating themſelves to the great people a hundred times.'

"The writers of this letter had probably received ill treatment from other ſtrangers. It was determined that they ſhould not continue to think ill of all who came to viſit them. On their return they were perhaps as much ſurpriſed to find their houſes ſtill entire, as their viſitors had been who found they were deſerted. Nothing was diſturbed; and a ſmall preſent, likely to be acceptable to the chief, was left for him in the principal dwelling, with a Chineſe letter, ſignifying, that 'the ſhips and people were Engliſh, who called merely for refreſhment, and on fair terms of purchaſe, without any ill intention; being a civilized nation, endowed with principles of humanity, which did not allow them to plunder or injure others who happened to be weaker or fewer than themſelves."

Pulo Lingen, another of this cluſter, is likewiſe a conſiderable iſland, remarkable for a mountain in its centre, terminating in a fork like Parnaſſus; but to which the unpoetical ſeamen beſtow the name of *aſſes ears*. Every day preſented new iſlands to the view, diſplaying a vaſt variety in form, ſize, and colour. Some iſolated, and ſome collected in cluſters. Many were clothed with verdure; ſome had tall trees growing on them; others were mere rocks, the reſort of innumerable birds, and whitened with their dung.

PUNCTUATION, in grammar, is an art with which we have ſaid, in the *Encyclopædia*, that the ancients were entirely unacquainted. Candour obliges us to

Punctuation. to confess that this was said rashly. A learned writer, in the Monthly Magazine for September 1798, who subscribes J. Warburton, has proved, we think completely, that the art is not wholly modern; and we shall lay his proofs, in his own words, before our readers.

"Some species of pauses and divisions of sentences in speaking and writing must have been coeval with the knowledge of communicating ideas by sound or by symbols. Suidas * says, that the *period* and the *colon* were discovered and explained by Thrasymacus, about 380 years before the Christian æra. Cicero † says, that Thrasymacus was the first who studied oratorical numbers, which entirely consisted in the artificial structure of periods and colons. It appears from a passage in Aristotle ‡, that punctuation was known in his time. The learned Dr Edward Bernard § refers the knowledge of pointing to the time of that philosopher, and says, that it consisted in the different positions of one single point. At the bottom of a letter, thus, (A.), it was equivalent to a comma; in the middle (A·) it was equal to a colon; at the top (A˙) it denoted a period, or the conclusion of a sentence.

* Qui primus periodum et colon monstravit. *Suidas de Thrasymacho.*
† *Cicero Orat.* § 33.
‡ *Rhet.* lib. iii. c. 9.
§ *Bern. Orbis erud. Literat.* tab. 30. edit. 1689.

"This mode was easily practised in Greek manuscripts, while they were written in capitals. But when the small letters were adopted, that is, about the 9th century, this distinction could not be observed; a change was therefore made in the scheme of punctuation. *Unciales literas hodierno usu dicimus eas in vetustis codicibus, quæ priscam formam servant, ac solutæ sunt, nec mutuo colligantur. Hujus modi literæ unciales observantur in libris omnibus ad nonum usque sæculum.*—Montf. Palæog. Recens. p. xii.

"According to Cicero, the ancient Romans, as well as the Greeks, made use of points. He mentions them under the appellation of *librariorum notæ;* and in several parts of his works he speaks of '*interpunctæ clausulæ in orationibus*,' of '*clausulæ atque interpuncta verborum*,' of '*interpunctiones verborum*,' &c. *.

"Seneca, who died A. D. 65, expressly says, that Latin writers, in his time, had been used to punctuation. '*Nos* †, *cum scribimus interpungere consuevimus.*' Muretus and Lipsius imagined that these words alluded to the insertion of a point after each word: but they cetainly were mistaken; for they must necessarily refer to marks of punctuation in the division of sentences, because in the passage in which these words occur, Seneca is speaking of one Q. Haterius, who made no pauses in his orations.

* *Cic. de Orat.* l. iii. § 26. ibid. 7. *Orat pro Murena*, § 25.
† *Sen. Epist.* 40.

"According to Suetonius, in his *Illust. Gram.* Valerius Probus procured copies of many old books, and employed himself in correcting, pointing, and illustrating them; devoting his time to this and no other part of grammar. *Multa exemplaria contracta emendare, ac distinguere et adnotare curavit; soli huic, nec ulli præterea, grammatices parti deditus.*

"It appears from hence, that in the time of Probus, or about the year 68, Latin manuscripts had not been usually pointed, and that grammarians made it their business to supply this deficiency.

"Quintilian, who wrote his celebrated treatise on Oratory about the year 88, speaks of commas, colons, and periods; but it must be observed, that by these terms he means clauses, members, and complete sentences, and not the marks of punctuation ‡.

"Ælius Donatus § published a treatise on Grammar in the 4th century, in which he explains the *distinctio*, the *media distinctio*, and the *subdistinctio;* that is, the use of a single point in the various positions already mentioned.

"Jerom *, who had been the pupil of Donatus, in his Latin Version of the Scriptures, made use of certain distinctions or divisions, which he calls *cola* and *commata*. It has, however, been thought probable, that these divisions were not made by the addition of any points or stops; but were formed by writing, in one line, as many words as constituted a clause, equivalent to what we distinguish by a comma or a colon. These divisions were called στιχοι or ρηματα; and had the appearance of short irregular verses in poetry. There are some Greek manuscripts still extant which are written in this manner †."

‡ *Quint.* l. ix. c. 4.
§ A.D. 340.
* *Hieron. Præf. in E. f..ian. Vide etiam. Præf. in Josuam*, &c. tom. iii. p. 26.
† *Vide Montf. Palæog. Græca*, lib. iii. c. 4.

Mr Warburton says, that the best treatise upon punctuation that he has seen, was published some years since by an anonymous author, and dedicated to Sir Clifton Wintringham, Bart. With that treatise we are not acquainted; but we do not think that the art of punctuation can be taught by rules. The only way to acquire it is to observe attentively how the most perspicuous writers dispose of their periods, colons, semicolons, and commas. This will make us acquainted with the importance of each; and then every writer, who knows his own meaning, must be capable of pointing his own pages more correctly than any other man.

PYRAMIDOID, is sometimes used for the parabolic spindle, or the solid formed by the rotation of a semiparabola about its base or greatest ordinate. See *Parabolic Spindle.*

Pyrites.

PYRITES. See Mineralogy in this *Supplement.*—In the third volume of Mr Nicholson's Philosophical Journal, we have a method of making artificial pyrites, which we shall give in the words of the author.

"I impregnated water (says he) very strongly with carbonic acid, and introducing some iron filings, I continued the impregnation for a day or two, and afterwards allowed the water to stand in a well-corked bottle for some days, till the acid had taken up as much iron as possible. I then poured it into an aerating apparatus; threw up the hepatic gas from sulphuret of potash and sulphuric acid; and after having agitated the water till it had got a good dose of the gas, I poured the water into a large bason: this was in the evening, and next morning when I looked at it, I found it covered with a pretty thick film of a most beautiful variegated pyrites. I had so little of it, that the only proof I had of its being this substance was, that it was ignited on its being placed on a hot poker."

QUADRATURE,

Q.

QUADRATURE, in geometry (fee that article, and likewife FLUXIONS, *Encycl.*), has employed the time and ingenuity of fome of the moft eminent mathematicians both of ancient and of modern times. Dr Halley's method of computing the ratio of the diameter of the circle to its circumference, was confidered by himfelf, and other learned mathematicians, as the eafieft the problem admits of. And although, in the courfe of a century, much eafier methods have been difcovered, ftill a celebrated mathematician of our own times has expreffed an opinion, that no other aliquot part of the circumference of a circle can be fo eafily computed by means of its tangent as that which was chofen by Dr Halley, viz. the arch of 30 degrees. Without taking upon him to determine whether this opinion be juft or not, the Rev. John Hellins has fhewn how the feries by which Dr Halley computed the ratio of the diameter to the circumference of the circle may be transformed into others of fwifter convergency, and which, on account of the fucceffive powers of $\frac{1}{80}$ which occur in them, admit of an eafy fummation. We fhall give the memoir in the author's own words.

"1. The propofed transformation is obtained by means of different forms in which the fluents of fome fluxions may be expreffed; and to proceed with greater clearnefs, "I will here (fays Mr Hellins) fet down the fluxion in a general form, and its fluent, in the two feries which are ufed in the following particular inftance, and may be applied with advantage in fimilar cafes.

"2. The fluent of $\frac{x^{m-1}\dot{x}}{1-x^n}$ is $= \frac{x^m}{m} + \frac{x^{m+n}}{m+n} + \frac{x^{m+2n}}{m+2n} + \frac{x^{m+3n}}{m+3n}$, &c. which feries, being of the fimpleft form which the fluent feems to admit, was firft difcovered, and probably is the moft generally ufeful. But it has alfo been found, that the fluent of the fame fluxion may be expreffed in feries of other forms, which, though lefs fimple than that above written, yet have their particular advantages. Amongft thofe other forms of feries which the fluent admits of, that which fuits my prefent purpofe is $\frac{x^m}{m.\overline{1-x^n}} - \frac{nx^{m+n}}{m.\overline{m+n}.\overline{1-x^n}|^2} + \frac{n.2n.x^{m+2n}}{m.\overline{m+n}.\overline{m+2n}.\overline{1-x^n}|^3} - \frac{n.2u.3n.x^{m+3}}{m.\overline{m+n}.\overline{m+2n}.\overline{m+3n}.\overline{1-x^n}|^4}$ + &c. which, to fay nothing of other methods, may eafily be inveftigated by the rule given in p. 64. of the third edition of *Emerfon's Fluxions;* or its equality with the former feries may be proved by algebra.

"3. On account of the fign — before x^n, in the laft feries, it may be proper to remark, that its convergency, by a geometrical progreffion, will not ceafe till $\frac{x^n}{1-x^n}$ becomes $= 1$, or x becomes $= \sqrt[n]{\frac{1}{2}}$; and that when x is a fmall quantity, and n a large number, this feries will converge almoft as fwiftly as the former. For inftance, if x be $= \sqrt{\frac{1}{3}}$, and $n = 8$, which are the values in the followiug cafe, the former feries will converge by the quantity $x^n = \sqrt{\frac{1}{3}}|^8, = \frac{1}{81}$, and this feries by the quantity $\frac{x^n}{1-x^n} = \frac{\frac{1}{81}}{1-\frac{1}{81}} = \frac{1}{80}$; where the difference in convergency will be but little, and the divifions by 80 eafier than thofe by 81.

"4. With refpect to the indices m and n, as they are here fuppofed to be affirmative whole numbers, and will be fo in the ufe I am about to make of them, the reader need not be detained with any obfervations on the cafes in which thefe fluents will fail, when the indices have contary figns.

"5. It may be proper further to remark, that by putting $\frac{x^n}{1-x^n} = z$, and calling the firft, fecond, third, &c. terms of the feries $\frac{x^m}{m.\overline{1-x^n}} - \frac{nx^{m+n}}{m.\overline{m+n}.\overline{1-x^n}|^2} + \frac{n.2nx^{m+2n}}{m.\overline{m+n}.\overline{m+2n}.\overline{1-x^n}|^3}$ + &c. A, B, C, &c. refpectively, the feries will be expreffed in the concife and elegant notation of Sir Ifaac Newton, viz. $\frac{x^m}{m.\overline{1-x^n}} - \frac{nzA}{m+n} + \frac{2nzB}{m+2n} - \frac{3nzC}{m+3n}$ + &c. which is well adapted to arithmetical calculation.

"6. I come now to the transformation propofed, which will appear very eafy, as foon as the common feries, expreffing the length of an arch in terms of its tangent, is properly arranged.

"If the radius of a circle be 1, and the tangent of an arch of it be called t, it is well known that the length of that arch will be $= t - \frac{t^3}{3} + \frac{t^5}{5} - \frac{t^7}{7} + \frac{t^9}{9} - \frac{t^{11}}{11} +$ &c. Now, if the affirmative terms of this feries be written in one line, and the negative ones in another, the arch will be

$$= \begin{cases} t + \frac{t^5}{5} + \frac{t^9}{9} + \frac{t^{13}}{13} + \frac{t^{17}}{17} + \text{\&c.} \\ -\frac{t^3}{3} - \frac{t^7}{7} - \frac{t^{11}}{11} - \frac{t^{15}}{15} - \frac{t^{19}}{19} - \text{\&c.} \end{cases}$$

And if, again, the firft, third, fifth, &c. term of each of thefe feries be written in one line, and the fecond, fourth, fixth, &c. in another, the fame arch will be expreffed thus:

$$= \begin{cases} + \begin{cases} t + \frac{t^9}{9} + \frac{t^{17}}{17} + \frac{t^{25}}{25} + \frac{t^{33}}{33} + \text{\&c.} \\ \frac{t^5}{5} + \frac{t^{13}}{13} + \frac{t^{21}}{21} + \frac{t^{29}}{29} + \frac{t^{37}}{37} + \text{\&c.} \end{cases} \\ - \begin{cases} \frac{t^3}{3} + \frac{t^{11}}{11} + \frac{t^{19}}{19} + \frac{t^{27}}{27} + \frac{t^{35}}{35} + \text{\&c.} \\ \frac{t^7}{7} + \frac{t^{15}}{15} + \frac{t^{23}}{23} + \frac{t^{31}}{31} + \frac{t^{39}}{39} + \text{\&c.} \end{cases} \end{cases}$$

All which feries are evidently of the firft form in article 2. and therefore their values may be expreffed in the fecond form there given, or more neatly the Newtonian notation mentioned in art. 5. In each of thefe feries the value of n is 8:

And the value of m, $\left\{\begin{array}{l}\text{in the first series, is } 1\,; \\ \text{in the second series, is } 5\,; \\ \text{in the third series, is } 3\,; \\ \text{in the fourth series, is } 7.\end{array}\right.$

" If now we take $t = \sqrt{\frac{1}{3}}$, the tangent of 30°, which was chosen by Dr Halley, we shall have the arch at 30°

$$= \left\{\begin{array}{l} + \left\{\begin{array}{l} \frac{1}{\sqrt{3}} \times : 1 + \frac{1}{9.81} + \frac{1}{17.81^3} + \frac{1}{25.81^3} + \frac{1}{33.81^4}, \text{ \&c.} \\ \frac{1}{9\sqrt{3}} \times : \frac{1}{5} + \frac{1}{13.81} + \frac{1}{21.81^2} + \frac{1}{29.81^3} + \frac{1}{37.81^4}, \text{ \&c.} \end{array}\right. \\ \hline - \left\{\begin{array}{l} \frac{1}{3\sqrt{3}} \times : \frac{1}{3} + \frac{1}{11.81} + \frac{1}{19.81^2} + \frac{1}{27.81^3} + \frac{1}{35.81^4}, \text{ \&c.} \\ \frac{1}{27\sqrt{3}} \times : \frac{1}{7} + \frac{1}{15.81} + \frac{1}{23.81^2} + \frac{1}{31.81^3} + \frac{1}{39.81^4}, \text{ \&c.} \end{array}\right. \end{array}\right.$$

Six times this quantity will be = the semicircumference when radius is 1, and = the whole circumference when the diameter is 1. If therefore we multiply the last series by 6, and write $\sqrt{12}$ for $\frac{6}{\sqrt{3}}$, and express their value in the form given in art. 5. we shall have the circumference of a circle whose diameter is 1,

$$= \left\{\begin{array}{l} + \left\{\begin{array}{l} \frac{81\sqrt{12}}{80} - \frac{8A}{9.80} + \frac{16B}{17.80} - \frac{24C}{25.80} + \frac{32D}{33.80}, \text{ \&c.} \\ \frac{81\sqrt{12}}{5.9.80} - \frac{8A}{13.80} + \frac{16B}{21.80} - \frac{24C}{29.80} + \frac{32D}{37.80}, \text{ \&c.} \end{array}\right. \\ \hline - \left\{\begin{array}{l} \frac{81\sqrt{12}}{3.3.80} - \frac{8A}{11.80} + \frac{16B}{19.80} - \frac{24C}{27.80} + \frac{32D}{35.80}, \text{ \&c.} \\ \frac{81\sqrt{12}}{7.27.80} - \frac{8A}{15.80} + \frac{16B}{23.80} - \frac{24C}{31.80} + \frac{32D}{39.80}, \text{ \&c.} \end{array}\right. \end{array}\right.$$

" 7. All these new series, it is evident, converge somewhat swifter than by the powers of 80. For in the first series, which has the slowest convergency, the coefficients $\frac{8}{9}$, $\frac{16}{17}$, $\frac{24}{25}$, &c. are each of them less than 1; so that its convergency is somewhat swifter than by the powers of 80.

" 8. But another advantage of these new series is, that the numerator and denominator of every term except the first, in each of them is divisible by 8: in consequence of which the arithmetical operation by them is much facilitated, the division by 80 being exchanged for a division by 10, which is no more than removing the decimal point. These series, then, when the factors which are common to both numerators and denominators are expunged, will stand as below (each of which still converging somewhat quicker than by the powers of 80), and we shall have the circumference of a circle whose diameter is 1,

$$= \left\{\begin{array}{l} + \left\{\begin{array}{l} \frac{81\sqrt{12}}{80} - \frac{A}{9.10} + \frac{2B}{17.10} - \frac{3C}{25.10} + \frac{4D}{33.10}, \text{ \&c.} \\ \frac{9\sqrt{12}}{400} - \frac{A}{13.10} + \frac{2B}{21.10} - \frac{3C}{29.10} + \frac{4D}{37.10}, \text{ \&c.} \end{array}\right. \\ \hline - \left\{\begin{array}{l} \frac{9\sqrt{12}}{80} - \frac{A}{11.10} + \frac{2B}{19.10} - \frac{3C}{27.10} + \frac{4D}{35.10}, \text{ \&c.} \\ \frac{3\sqrt{12}}{7.80} - \frac{A}{15.10} + \frac{2B}{23.10} - \frac{3C}{31.10} + \frac{4D}{39.10}, \text{ \&c.} \end{array}\right. \end{array}\right.$$

" By which series the arithmetical computation will be much more easy than by the original series."

Quadrature Lines, or *Lines of Quadrature*, are two lines often placed on Gunter's sector. They are marked with the letter Q, and the figures 5, 6, 7, 8, 9, 10; of which Q denotes the side of a square, and the figures denote the sides of polygons of 5, 6, 7, &c. sides. Also S denotes the semidiameter of a circle, and 90 a line equal to the quadrant or 90° in circumference.

QUADRIPARTITION, is the dividing by 4, or into four equal parts. Hence *quadripartite*, &c. the 4th part, or something parted into four.

QUADRUPLE, is four fold, or something taken four times, or multiplied by 4; and so is the converse of quadripartition.

QUART, a measure of capacity, being the quarter or 4th part of some other measure. The English quart is the 4th part of the gallon, and contains two pints. The Roman quart, or quartarius, was the 4th part of their congius. The French, besides their quart or pot of two pints, have various other quarts, distinguished by the whole of which they are quarters; as *quart de muid*, and *quart de boisseau*.

QUARTILE, an aspect of the planets when they are at the distance of three signs or 90° from each other; and is denoted by the character □.

QUELPAERT, an island lying in the mouth of the channel of Japan, and subject to the king of Corea (See that article *Encycl.*) Till the last voyage of La Perouse, this island was known to Europeans only by the wreck of the Dutch ship Sparrow-hawk in 1635. On the 21st of May 1787, the French Commodore made this island, and determined the south point of it to be in Lat. 33° 14′ north, and in Lon. 124° 15′ east from Paris. He ran along the whole south-east side, at six leagues distance, and says that it is scarcely possible to find an island which affords a finer aspect; a peak of about a thousand toises, which is visible at the distance of eighteen or twenty leagues, occupies the middle of the island, of which it is doubtless the reservoir; the land gradually slopes towards the sea, whence the habitations appear as an amphitheatre. The soil seemed to be cultivated to a very great height. By the assistance of glasses was perceived the division of fields; they were very much parcelled out, which is the strongest proof of a great population. The very varied gradation of colours, from the different states of cultivation, rendered the view of this island still more agreeable. Unfortunately, it belongs to a people who are prohibited from all communication with strangers, and who detain in slavery those who have the misfortune to be shipwrecked on these coasts. Some of the Dutchmen of the ship Sparrow-hawk, after a captivity of eighteen years there, during which they received many bastinadoes, found means to take away a bark, and to cross to Japan, from which they arrived at Batavia, and afterwards at Amsterdam.

QUEUE d'aronde, or *Swallow's Tail*, in fortification, is a detached or outwork, whose sides spread or open towards the campaign, or draw narrower and closer towards the gorge. Of this kind are either single or double tenailles, and some horn-works, whose sides are not parallel, but are narrow at the gorge, and open at the head, like the figure of a swallow's tail. On the contrary, when the sides are less than the gorge, the work is called *contre queue d'aronde*.

Queue, Quintal. *Queue d'aronde*, in carpentry, a method of jointing, called alſo *dove-tailing*.

QUINTAL, the weight of a hundred pounds, in moſt countries: but in England it is the hundred weight, or 112 pounds. Quintal was alſo formerly uſed for a weight of lead, iron, or other common metal, uſually equal to a hundred pounds, at 6 ſcore to the hundred.

Quintile. QUINTILE, in aſtronomy, an aſpect of the planets when they are diſtant the 5th part of the zodiac, or 72 degrees; and is marked thus, C, or O.

R.

Rachitis. RACHITIS, RICKETS (See MEDICINE-*Index*, *Encycl.*), is a diſeaſe ſo formidable to children that we believe no parent will think the following abſtract of *Bonhomme's* memoir on the nature and treatment of it too long even for this *Supplement*.

The change which the bones undergo in this diſorder, has long been attributed to the action of an acid on their ſubſtance; but this ſuppoſition was grounded on mere conjecture and remote analogy. Bonhomme holds the ſame opinion on better grounds; and the principal notions which conſtitute the baſis of his memoir are the following:

1. According to him, the nature of the rachitic diſorder ariſes, on the one hand, from the developement of an acid approaching in its properties to the vegetable acids, particularly the oxalic; and, on the other, from the defect of phoſphoric acid, of which the combination with the animal calcareous earth forms the natural baſis of the bones, and gives them their ſolidity. Whence it follows, that the indication reſulting from this propoſition, if once adopted, would be, that the treatment of rachitis muſt depend on two principal points, namely. to prevent the developement of the oxalic acid, and to re-eſtabliſh the combination of the phoſphoric acid with the baſis of the bones to which they owe their ſolidity.

2. The author proves, by experiments and obſervations, in the firſt place, that alkaline lotions of the parts affected with rachitis contribute to their cure; next, that the calcareous phoſphate taken internally is really tranſmitted by the lymphatic paſſages, and contributes to oſſification; and, laſtly, that the internal uſe of calcareous phoſphate, whether alone or combined with the phoſphate of ſoda, powerfully contributes to reſtore the natural proportions in the ſubſtance of the bones, and accelerate the cure of rachitis.

With regard to the author's endeavours to prove that the calcareous acid is wanting in the bones of thoſe who are diſordered with rachitis, and that the developement of oxalic acid contributes to the diſeaſe, we muſt not conceal that his memoir contains views rather than abſolute proofs of theſe two poſitions, He declares, himſelf, he was not provided with the neceſſary means to eſtabliſh an exact and complete analyſis. He therefore preſents his ideas, in this reſpect, merely as conjectures approaching to the truth.

The effect of the action of acids upon bones was before known; that is to ſay, that when deprived of calcareous phoſphate, and reduced to the gelatinous parenchyma which forms one of their elements, they loſe their conſiſtence, and become flexible. Hence it was already conjectured by various phyſicians, that the rachitis was the effect of a peculiar acid.

A diſpoſition to aſceſcence in the firſt paſſages is obſervable in all infants. The odour which characterizes this aceſcence is often manifeſt in their breath, and even their perſpiration. The bile corrects this diſpoſition; but in general the bile is wanting in rachitic infants. It does not colour their excrements, and the acids accordingly are developed in a very decided manner. They diſturb the circulation, and attack and ſoften the bones. As it is by defect of animalization that theſe acids develope themſelves, it follows that their character is analagous to the fermenteſcible vegetable acids, and more or leſs to the oxalic acid; and that, on the contrary, the animal acid or phoſphoric acid ceaſes to be formed, and to unite with the animal calcareous earth; whence they are deprived of the principle of their ſolidity. This is the theory of Citizen Bonhomme.

In order to eſtabliſh this doctrine upon preciſe experiments, it was requiſite to analyſe rachitic bones comparatively with thoſe of healthy individuals of the ſame age; and as it is known that the urine of rachitic ſubjects depoſites a great quantity of a ſubſtance of ſparing ſolubility and earthy appearance, it would have been advantageous to have joined a complete analyſis of this urine and its ſediment. Citizen Bonhomme, not being provided with the means ſufficient to make theſe analyſes, and being beſides of opinion that ſuch rachitic bones as are deſtroyed by this malady exiſt in a progreſſive ſtate of change, which might render their analyſis ſcarcely ſuſceptible of compariſon, limited himſelf to a collection of ſome of the moſt remarkable phenomena of the urine, of the aged, the adult, and infants in the healthy ſtate, of infants in the rachitic ſtate, and of patients after the perfect cure of this diſorder. From theſe obſervations he has deduced ſeveral important reſults.

It is known, that when the urine contains diſengaged phoſphoric acid, as happens to aged individuals, and in ſome peculiar circumſtances of the ſyſtem, if lime water be poured in, there is a ſpeedy depoſition of calcareous phoſphate. It is alſo known, that when a ſolution of the nitrate of mercury is poured to the freſh urine of adults, a roſe-coloured precipitate is formed, which is a phoſphate of mercury produced by the decompoſition of the phoſphates contained in the urine. Theſe two proofs are therefore extremely proper to aſcertain the preſence of phoſphoric acid, whether free or combined, in a fluid which in its natural ſtate contains a remarkable proportion. Beſides this principle, the urine depoſits more or leſs of ſediment, either gelatinous or of an earthy appearance; and, laſtly, by evaporation, a ſaponaceous and ſaline extract, in greater or leſs abundance, is obtained by evaporation. By means of theſe four methods of examination, the author has aſcertained the following facts:

1. In the healthy ſtate, the ſediment naturally depoſited by urine is almoſt totally gelatinous in the infant and the adult, and in the aged individual it is ſurcharged with an abundant ſediment of an earthy appearance ſimilar to the earth of bones, which conſequently is calcareous phoſphate. 2. The quantity of brown ſaponaceous ſaline extract afforded by evaporation is greater in proportion to the age. 3. The preſence of diſengaged phoſphoric acid, as ſhewn by lime water, is none in the urine of infants, ſcarcely perceptible in that of adults, but very remarkable in that of old men. For two ounces of this laſt urine afforded by this means ten grains of phoſphate of lime. 4. The decompoſition of the phoſphates by nitrate of mercury is not ſeen in the urine of infants; an abundant precepitate of a light roſe-colour is produced in this way from the urine of adults; and in that of old men this precipitate is always of a grey colour, and very abundant. Hence Citizen Bonhomme concludes, that the phoſphoric acid, whether at liberty or combined, does exiſt in the urine of healthy individuals in proportion to the deſtruction of the ſolids by age, and that it increaſes with the age.

With regard to the urine of rachitic ſubjects, the moſt remarkable facts are, 1. The abundant and apparently earthy ſediment it depoſits (ſpontaneouſly) is different from that of old men, by its colour, which is grey, and does not reſemble phoſphate of lime, and alſo by its much greater quantity. For a pound of this urine let fall two gros, whereas the ſame quantity of the urine of old men depoſited only 45 grains. 2. The extract left by evaporation is likewiſe much more conſiderable than in other urine. It is one third more in quantity than the extract afforded even by the urine of aged perſons.

From theſe two firſt obſervations it follows, that the ſolids in rachitic ſubjects are deſtroyed with much more rapidity than even in old men; and that they afford a much more abundant portion of waſte to the urine.

3. The light depoſition occaſioned by lime water in the urine of rachitic ſubjects is very ſmall in quantity, brown, gelatinous when freſh, and pulverulent when dry. It does not at all reſemble calcareous phoſphate. 4. The depoſition formed by the ſolution of mercurial nitrate is not abundant, neither of a roſe colour as in the urine of adults, nor grey like that of old men. It is always white, and conſequently has no external reſemblance to the phoſphate of mercury. The author affirms that it reſembles a mercurial oxalate. Laſtly, the urine of the ſame rachitic ſubjects, when cured, exhibits again all the characters obſerved in the urine of healthy children. We ſhall not add to the reflections of the author. In effect, though theſe firſt obſervations are curious, they are incomplete. We offer them to phyſicians ſimply as the elements of an inveſtigation which it is of importance to continue and bring to perfection. We ſhall therefore proceed to the curative and experimental parts of the memoir.

One of the facts which it was of the utmoſt importance to eſtabliſh, was the tranſition of the calcareous phoſphate from the inteſtinal paſſages, into thoſe of circulation and ſecretion. Fourcroy had already well aſcertained that the ſerum of milk contains the ſalt naturally. Vauquelin had proved its exiſtence, as well as that of pure ſoda, in the ſeminal fluid; but was it poſſible that it could paſs unaltered from the ſtomach and inteſtines into the veſſels which contain the blood and lymph? Could it by this means apply itſelf to the bones? This was to be aſcertained by experiments; and the following are the experiments made by Bonhomme for that purpoſe. We give them in a tranſlation of his own words.

"I cauſed (ſays he) ſeveral young fowls of the ſame incubation to be fed in different manners. Some received the uſual food without any mixture; others received daily a certain quantity of calcareous phoſphate mixed in the ſame paſte as formed the ſupport of the others; and, laſtly, one of them was fed with variations in the uſe of the mixture; the calcareous phoſphate was ſometimes given and ſometimes ſuſpended. When theſe fowls, after two months, had acquired their ordinary growth, I examined and carefully compared the ſtate of their bones. The progreſs of the oſſification in the epiphyſes was various according to the nature of the food the animal had received. The bones of the laſt fowl, which had received the phoſphate only from time to time, were rather more advanced than the bones of thoſe which had been fed without mixture. The bones of thoſe fowls which had been habitually fed with the mixture were evidently more ſolid, and their epiphyſes were much leſs perceptible. Simple inſpection was ſufficient to ſhew theſe differences when the bones were mixed together.

"I had fed ſeveral young fowls of the ſame incubation according to another plan. Some were fed on a ſimple paſte, without mixture; for others it was mixed with pulveriſed madder-root; and a third compoſition was made of this laſt paſte and calcareous phoſphate. This was alſo given habitually to other fowls. When after two months I examined the progreſs of oſſification in the bones of theſe different animals, I eaſily perceived the red traces of the madder in the oſſified parts of all thoſe which had uſed it; but I obſerved, that the oſſification was not more advanced by the ſimple mixture of this root than by the ordinary food: on the contrary, the bones of thoſe fowls which had ſwallowed the phoſphate mixed with madder were much more ſolid than the others. The red colour ſerved admirably to diſtinguiſh the extremities of the long bones from their epiphyſes. After an exact compariſon, there could be no doubt of the efficacy of calcareous phoſphate in favour of the progreſs of oſſification. The virtue of the madder ſeemed confined to that of giving colour to the oſſified parts."

From theſe experiments, it was natural to make the trial of calcareous phoſphate in addition to the remedies made uſe of in the treatment of rachitic ſubjects. Here follows what the author himſelf ſays of two remarkable inſtances in which the calcareous phoſphate was adminiſtered with ſucceſs:

"The daughter of Mr Ranchon watch-maker, aged two years and a half, walked with a feeble and tottering pace, and the extremities of all her bones preſented epiphyſes very

very prominent. In this fituation fhe exhibited the appearance of imperfect rachitis, or the firft period of this diforder. Alkaline lotions, which I immediately advifed, were attended with a good effect. Her fleep became more firm; and as the firft paffages were in a good ftate, I gave, without internal preparation, one fcruple of a mixture of equal parts of phofphate of lime and phofphate of foda twice a day. In the courfe of three weeks her legs were perfectly reftored; and this amiable infant has ever fince had the fatisfaction to run with fpirit and agility.

" A female infant, of the name of Boiard, aged four years, had experienced from her birth the moft decided fymptoms of rachitis. The protuberance of the epiphyfes and tumefaction of the abdomen firft indicated the difeafe. The impoffibility of fupporting herfelf and walking at the ufual age confirmed thefe unfortunate fymptoms. By degrees the glands of the neck and of the mefentary became fwelled; the teeth were blackened, became carious, and were not replaced. This fituation became ftill more afflicting by crifes almoft periodical at an interval of three or four weeks. At thefe afflicting periods, a fever of confiderable ftrength, cardialgia, and even convulfions, particularly in the night, were obferved. The termination of each paroxyfm was announced or afcertained by abundant ftools, and the evacuation of urine ftrongly charged with an earthy fediment. The imprudent exhibition of a purge at the beginning of one of thefe crifes had nearly deprived the patient of her life. In this ftate it was that I beheld her for the firft time in the month of January 1791. The alkaline lotion was the only remedy the mother adopted in the firft inftance, and it produced a remarkable effect. After eight days the infant was fo much better as to be able to fupport herfelf. The remedy was then laid afide, and eight days afterwards the child was incapable of ftanding without fupport. The ufe of the alkaline folution being renewed, was attended with the fame fuccefs, and its difcontinuance was again followed by the complete return of all the fymptoms. In the firft days of March, the other remedies I had advifed were exhibited. The conftipation which had always exifted became lefs, and the following crifis was effected without pain. And at length the convulfions, the pains, and the crifes difappeared; but the impoffibility of walking ftill remained. At this time, namely, on the fecond of May, I gave the child the phofphate of foda and calcareous phofphate mixed together, in the dofe of half a dram twice a-day. At the end of the month fhe was able to ftand upright, leaning againft a chair, and the fwellings began to diminifh. She continued for a long time afterwards to take the mixture of the phofphates. I likewife gave her occafionally one grain of the extract of bile, prepared with fpirit of wine; and at length in the month of July I had the pleafure to fee the patient run and play in the middle of the ftreet with the other children of her own age, &c."

The author gives other inftances of this medicine being adminiftered with complete fuccefs to rachitic children, and one in which it was attended with the beft effects in a cafe of incurvated fpine. Thefe it is needlefs to infert, becaufe we truft that none of our lefs learned readers will have recourfe to the medicine without the advice of a phyfician; and to him an enumeration of cafes could ferve no purpofe. It may be proper, however, as alkaline lotions and their beneficial effects are mentioned, to give here the author's account of the lotion which he ufed.

" In ordinary cafes of rachitis, particularly at the commencement of the diforder, it is of advantage to ufe a fimple folution of pot-afh to wafh the parts affected. This folution is made by diffolving from half an ounce to an ounce of purified pot-afh in a pound of diftilled or very pure fpring-water. When it is to be ufed, the fkin muft firft be rubbed with a dry cloth, or a piece of fine flannel. After this precaution, the difeafed extremities are to be wafhed carefully with the warm folution, and at length wiped, fo as to leave no trace of moifture. This practice and wafhing muft be repeated at leaft twice a-day. I can affirm, from repeated trials, that it will foon be attended with fuccefs."

In a note on this paffage, M. Hallé, who analyfed the memoir at the defire of the Society of Medicine at Paris, juftly obferves, that as pure potafs, or the vegetable alkali, is a moft powerful cauftic, it cannot be ufed in thefe proportions; adding, that he found one-eighth part of the falt here indicated to form too ftrong a lotion for the fkin of an infant. M. Bonhomme, upon enquiry being made, informed him that the potafs which he ufed was that of the fhops, which is very far from being pure; and Mr Nicholfon conjectures that it was the common falt of tartar of our fhops. This, we think, extremely probable, efpecially as M. Bonhomme affures us that even a lixivium of wood-afhes, fuch as is ufed for wafhing fine linen, may anfwer the purpofe extremely well.

For a fuller account of this interefting memoir our readers are referred to the 17th volume of the *Annals de Chimie*, or to the firft volume of *Nicholfon's Philofophical Journal*.

RAJA, the *ray fifh*. See *Encyclopædia*, where it is faid that the *oxyrinchus* or fharp nofed ray, is fuppofed to be the *bos* of the ancients; but if there be any truth in the following narrative, which we confefs has much the air of fiction, this is probably a miftake. It is the narrative of Vaillant, and we fhall give it in his own words.

" In the latitude of 10° 15′ north, and longitude 355°, an enormous flat fifh of the ray genus (fays he), came and fwam round our veffel. It differed from the common ray, however, in the fhape of its head, which, inftead of being pointed, formed a crefcent, and from the extremities of the femicircle iffued two arms as it were, which the failors called horns. They were two feet wide at the bafe, and only five inches at the extremity. This monfter they told me was called the *fea-devil*.

" A few hours after, we faw two others with this, one of which was fo extremely large, that it was computed by the crew to be *fifty* or *fixty* feet wide. Each fwam feparately, and was furrounded by thofe fmall fifh which ufually precede the fhark, and which are therefore called by feamen *pilot-fifh*. Laftly, all three carried on each of their horns a white fifh, about the fize of a man's arm, and half a yard long, which appeared to be ftationed there on duty.

" You would have faid they were two fentinels placed to keep watch for the fafety of the animal, to inform him of any approaching danger, and to guide his movements. If he approached too near the veffel, they quitted their pofts, and, fwimming brifkly before, led him

him away. If he rofe too high above the water, they paffed backward and forward over his back till he had defcended deeper. If, on the contrary, he fwam too low, they difappeared, and we faw no more of them, becaufe, no doubt, they were paffing underneath, as in the preceding inftance they had paffed above him. Accordingly we found him reafcend towards the furface, and then the two fentinels reaffumed their pofts, each on his horn."

Thefe manœuvres continued three days; and to give our author the better opportunity of obferving them, the fhip moft fortunately was becalmed the whole time. He was naturally very defirous of catching one of them that he might examine it at leifure; and, by bribing the feamen with a dozen of bottles of wine, he accomplifhed his object. One of the fifh was ftruck with twelve or fifteen harpoons; feveral halfers were paffed round his body, and he was hoifted on board.

"This (fays our author) was the leaft of the three, being only *eight-and-twenty* feet in its extreme breadth, and *one-and-twenty* in length from the extremity of the horns to that of the tail. The tail, which was thick in proportion to the body, was *twenty-two inches* long. The mouth, placed exactly like that of the ray, was wide enough to fwallow a man with eafe. The fkin was white under the belly, and brown on the back, like that of the ray. We reckoned the animal to weigh not lefs, certainly, than a ton."

We think it was fortunate that they chanced to ftrike the fmalleft fifh; for an addition of eight or ten ton weight, which the largeft ray muft have weighed, as certainly as the fmalleft weighed one ton, might have been very inconvenient on board a fhip already loaded. We do not remember to have anywhere met with a defcription of this ray before, and we think it fhould be confidered as a new fpecies; but we fhall not give it a name till its exiftence be better afcertained, when we fubmit to the pupils of Linnæus, whether it may not be proper to give it the ancient name *bos*.

RAJAH (See *Encycl.*) We learn from Sir Charles Roufe Boughton's *Differtation concerning the Landed Property of Bengal*, that this title is conferred upon Hindoos by the Emperor, and frequently given out of courtefy to the greater zemindars. It would appear therefore that the Rajahs can never be independent of the Mogul but by a fuccefsful rebellion.

RAYEL UL-MULK, in the language of Bengal, the ufage of the country, the common law

RATIO (See *Encycl.*) has been defined by Euclid, in the 5th book of his Elements, in terms to which many mathematicians have objected; and his definition of proportion, which is fo ultimately connected with it, is ftill more objectionable. The Rev. Abraham Robertfon of Oxford, in a fmall tract publifhed in 1789, demonftrates the truth of the two definitions in queftion in feven propofitions, of which the fubftance is as follows. He firft lays down thefe four definitions:

"1. Ratio is the relation which one magnitude has to another, of the fame kind, with refpect to quantity.

"2. If the firft of four magnitudes be exactly as great when compared to the fecond, as the third is when compared to the fourth, the firft is faid to have to the fecond the fame ratio that the third has to the fourth.

"3. If the firft of four magnitudes be greater, when compared to the fecond, than the third is when compared to the fourth, the firft is faid to have to the fecond a greater ratio than the third has to the fourth.

"4. If the firft of four magnitudes be lefs, when compared to the fecond, than the third is when compared to the fourth, the firft is faid to have to the fecond a lefs ratio than the third has to the fourth."

He then demonftrates, by reafoning ftrictly geometrical, the following propofitions:

Prop. 1. If the firft of four magnitudes have to the fecond the fame ratio which the third has to the fourth; then, if the firft be equal to the fecond, the third is equal to the fourth; if greater, greater; if lefs, lefs.

Prop. 2. If the firft of four magnitudes be to the fecond as the third to the fourth, and if any equimultiples whatever of the firft and third be taken, and alfo any equimultiples of the fecond and fourth; the multiple of the firft will be to the multiple of the fecond as the multiple of the third to the multiple of the fourth.

Prop. 3. If the firft of four magnitudes be to the fecond as the third to the fourth, and if any like aliquot parts whatever be taken of the firft and third, and any like aliquot parts whatever of the fecond and fourth, the part of the firft will be to the part of the fecond as the part of the third to the part of the fourth.

Prop. 4. If the firft of four magnitudes be to the fecond as the third to the fourth, and if any equimultiples whatever be taken of the firft and third, and any whatever of the fecond and fourth; if the multiple of the firft be equal to the multiple of the fecond, the multiple of the third will be equal to the multiple of the fourth; if greater, greater; if lefs, lefs.

Prop. 5. If the firft of four magnitudes be to the fecond as the third is to a magnitude lefs than the fourth, then it is poffible to take certain equimultiples of the firft and third, and certain equimultiples of the fecond and fourth, fuch, that the multiple of the firft fhall be greater than the multiple of the fecond, but the multiple of the third not greater than the multiple of the fourth.

Prop. 6. If the firft of four magnitudes be to the fecond as the third is to a magnitude greater than the fourth, then certain equimultiples can be taken of the firft and third, and certain equimultiples of the fecond and fourth, fuch, that the multiple of the firft fhall be lefs than the multiple of the fecond, but the multiple of the third not lefs than the multiple of the fourth.

Prop. 7. If any equimultiples whatever be taken of the firft and third of four magnitudes, and any equimultiples whatever of the fecond and fourth; and if when the multiple of the firft is lefs than that of the fecond, the multiple of the third is alfo lefs than that of the fourth; or if when the multiple of the firft is equal to that of the fecond, the multiple of the third is alfo equal to that of the fourth; or if when the multiple of the firft is greater than that of the fecond, the multiple of the third is alfo greater than that of the fourth: then, the firft of the four magnitudes fhall be to the fecond as the third to the fourth.

RATIONAL, in arithmetic, &c. the quality of numbers, fractions, quantities, &c. when they can be expreffed by common numbers; in contradiftinction to irrational or furd ones, which cannot be expreffed in common numbers.

RAYNAL (William Thomas), commonly called the Abbé Raynal, was educated among the Jefuits, and had become one of the order. The learning of that Society is univerfally

Raynal. universally known as well as the happy talents which its superiors possessed, of assigning to each member his proper employment. Raynal, however, after having acquired among them a taste for literature and science, had probably become refractory, for he was expelled from the order; and the cause of his expulsion, according to the Abbé Barruel, was his impiety.

With the real cause of his expulsion M. Barruel is surely much better acquainted than we can pretend to be; but we have a strong suspicion that his impieties had not then reached farther than to call in question the supreme authority of the church; for our author himself assures us, that he did not utter his atrocious declarations against Christianity 'till he had ceased to be a member of the order of Jesuits. He then associated himself with Voltaire, D'Alembert, and Diderot, and was by them employed to furnish the theological articles for the *Encyclopédie*. But though his religious opinions were certainly lax, and his moral principles very exceptionable, he could not even then be what, in a Protestant country, would be deemed a man remarkable for impiety; for he employed the Abbé Yvon, whom M. Barruel calls an odd metaphysician, but an inoffensive and upright man, to write the articles which he was engaged to furnish. In the conducting of this transaction, he shewed, indeed, that he possessed not a proper sense of honour; for he paid poor Yvon with twenty-five louis d'ores for writing theological articles, for which he received himself six times that sum. This trick was discovered, Raynal was disgraced, and compelled to pay up the balance to Abbé Yvon; but tho' he had thus shewn himself to be without honour, it is difficult to believe that he had yet proceeded so far as to blaspheme Christ, since he had employed a Christian divine to supply his place in the *Encyclopédie*.

His first work of eminence, and that indeed upon which his fame is chiefly built, is his "Political and Philosophical History of the European Settlements in the East and West Indies." That this history is written in an animated style, and that it contains many just reflections, both political and philosophical, is known to all Europe; for it has been translated into every European language. Its beauties, however, are deformed by many sentiments that are irreligious, and by some that are impure. It was followed, we think, in 1780, by a small tract entitled "The Revolution of America;" in which the author pleads the cause of the revolted colonists with a degree of zeal, censures the conduct of the British government with a keenness of asperity, and displays a knowledge of the principles and intrigues of the different factions which at that period divided the English nation, that surely was not natural to the impartial pen of a philosophic foreigner. Hence he has been supposed to have been incited to the undertaking, and to have been furnished with part of his materials, by that desperate faction which uniformly opposed the measures of Lord North, and secretly fomented the rebellion in America. Be this as it may, he propagated, both in this tract and in his history, a number of licentious opinions respecting government and religion, of which he lived to regret the consequences.

A prosecution was instituted against him by the French government on account of his history of the East and West Indies; but it was conducted with so little severity that he had sufficient time to retire to the dominions of Raynal. the King of Prussia, who afforded him the protection he solicited, although his Majesty's character was treated by the author in his book with no great degree of veneration. Raynal also experienced the kindness of the Empress of Russia; and it is not a little remarkable of this singular personage, that although he was always severe in discussing the characters of princes, yet the most despotic among these heaped upon him many marks of favour and generosity. The Abbé also received a very unusual mark of respect from a British House of Commons. It was once intimated to the speaker that Raynal was a spectator in the gallery. The business was immediately suspended, and the stranger conducted to a more convenient and honourable situation. How different was the conduct of Dr Johnson, who, when a friend advanced to him with our author, saying, "Will you give me leave, Doctor, to introduce to you the Abbé Raynal?" turned on his heel, and vociferated, "No, Sir!" We are far from wishing to vindicate the rudeness of the sage; but it was perhaps as proper as the politeness of the House of Commons.

The great trait of Raynal's character was a love of liberty, which, in his earlier writings, he did not properly define; but when he lived to see some of the consequences of this, in the progress of the French Revolution, he made one glorious effort to retrieve his errors. In the month of May 1791, he addressed to the constituent assembly one of the most eloquent, argumentative, and impressive letters that ever was written on any subject; a letter which, if the majority of them had not been intoxicated with their newly acquired consequence, must have given some check to their mad career. After complimenting them upon what they had done, he proceeds thus: "I have long dared to speak to kings of their duty; suffer me now to speak to the people of their errors, and to their representatives of the dangers which threaten us. I am, I own to you, deeply afflicted at the crimes which plunge this empire into mourning. Is it true that I am to look back with horror at myself for being one of those who, by feeling a noble indignation against arbitrary power, may perhaps have furnished arms to licentiousness? Do then religion, the laws, the royal authority, and public order, demand back from philosophy and reason the ties which united them to the grand society of the French nation, as if, by exposing abuses, and teaching the rights of the people and the duties of princes, our criminal efforts had broken those ties? But, no!—never have the bold conceptions of philosophy been represented by us as the strict rule for acts of legislation.

"You cannot justly attribute to us what could only be the result of a false interpretation of our principles. Alas! now that I stand on the brink of the grave; now that I am about to quit this immense family, whose happiness I have ardently desired, what do I see around me? Religious troubles, civil dissensions, consternation on the one hand, tyranny and audacity on the other; a government the slave of popular tyranny; the sanctuary of the laws surrounded by unruly men, who alternately dictate or despise those laws; soldiers without discipline; leaders without authority; ministers without means; a king, the first friend of his people, plunged into bitterness, insulted, menaced, stripped of all authority; and the public power no longer existing but in in clubs, in which ignorant and rude men dare to decide all political queftions."

He then proceeds to prove, which he does very completely, that it was not the bufinefs of the affembly to abolifh every ancient inftitution; that the genius of the French people is fuch, that they never can be happy or profperous but under a well regulated monarchical government; and that, if they wifhed not the nation to fall under the worft kind of defpotifm—the defpotifm of a low faction, they muft increafe the power of the king. "Alas! (continues he) what are my fufferings, when in the heart of the capital, in the centre of knowledge, I fee this mifguided people welcome, with a ferocious joy, the moft criminal propofitions, fmile at the recital of murder, and celebrate their crimes as conquefts."

He had then feen comparatively but little; but he lived to fee more—to fee his countrymen celebrate, as virtues, crimes, compared with which the atrocities of 1790 appear almoft as harmlefs. Being ftripped of all his property, which was large, by the robbers of the revolution, he died in poverty in March 1796, and in the 84th year of his age.

Befides the works which we have already mentioned, he wrote "A Hiftory of the Parliament of England," and a "Hiftory of the Stadholderate;" but thefe are both of them more remarkable for a fpecious ftyle and loftinefs of invention than for ufeful obfervation or folid argument. He wrote likewife "The Hiftory of the Divorce of Catharine of Arragon by Henry the Eighth," which is not fo much a recital of, and commentary upon, the fact from which he takes the title, as it is an able picture of univerfal Europe at that period, of the views, interefts, and power, of all the different potentates. At the time of his death he was preparing a new edition of all his works, in which were to be made many alterations; and he is faid to have left among his manufcripts a "Hiftory of the Revocation of the Edict of Nantes," in four volumes; but it is alfo very certain, that, during the fanguinary reign of Robefpierre, he burnt a great part of his papers.

REAPING, the well-known operation of cutting corn either by the fickle or by the fcythe. Reaping by the fickle is by much the moft common practice, and that which, we believe, prevails univerfally in Scotland; yet the other method, where it is practicable, is certainly the leaft laborious, and by much the moft expeditious. To the fcythe, as an inftrument of reaping, many objections are urged.

It is faid that it fhakes the ear, fo that many of the grains are loft; that it lets the corn fall, after cutting it, in a confufed and fcattered ftate, fo that either much of it is loft, or a great deal of time is confumed in gathering it together; that it can only be made ufe of in land which is very even and free from ftones; that it does not leave fufficient length of ftubble in the ground to lay the corn on when cut; that it mixes bad weeds with the corn, the feeds of which are fown the next year; and, laftly, that the ufe of the fcythe is prejudicial to the health of the reaper.

Thefe objections, however, are either of no weight, or they are made by thofe who are not acquainted with the fcythes which have been adapted to this purpofe, and with the proper manner of ufing them. With a good fcythe, properly managed, the corn, after being cut, remains at firft upright, and then falls very gently upon the rake fixed to the fcythe, without any fhake or jolt; or at leaft with lefs than that which it receives when reaped with a fickle. With refpect to the lofs of grain, that proceeds chiefly from the corn being too dry; confequently it fhould be reaped only upon proper days, and proper times of the day, which is much more eafily done with the fcythe than with the fickle, becaufe the work is fo much fhorter. The ftalks, kept together by the rake, may be laid upon the ground, or rather againft the corn not yet cut, in fo regular and collected a ftate, that thofe who gather and tie the fheaves, whether they are women or children, have nothing but their own negligence to accufe if any thing is left behind. When land is properly ploughed and harrowed, it is fufficiently even; and in fuch as is ftony, the only precaution neceffary is to keep the fcythe a little higher in ufing it, that it may not ftrike againft the ftones. If the ftubble left in the ground be fhort, the ftraw which is cut off will be the longer; and the latter is certainly of more value than the former, which only ferves to incommode the cattle which afterwards go to feed in the field.

Thefe confiderations, and others of a like nature, induced the patriotic fociety of Milan to fend, fome years ago, to thofe parts in which fcythes are made ufe of for reaping; and having procured a model of a fcythe from Silefia, they caufed one to be made of a proper fize. It was firft tried upon corn, and afterwards upon millet; and although the firft fcythe was not accurately made, and the reaper had never before made ufe of fuch an inftrument, yet it was found that nearly half the ufual time was faved, and that the labour and fatigue were much diminifhed; the corn alfo was cut without receiving any fhock that could be hurtful to it, and fell in an even and regular ftate, fo that it was afterwards eafily bound up in compact fheaves. They were afterwards prefented with a fcythe fomewhat different from the Silefian, which is very geneally ufed in Auftria.

Thefe inftruments are fo fimple, that the figure of one of them renders the defcription of either almoft unneceffary. In fig. 1. is fhewn the Silefian fcythe tried by the Society; the difference between that and the Auftrian one we fhall mention in our defcription. The firft, or Silefian fcythe, differs very little from the fcythe we commonly ufe for mowing grafs, except that the blade is rather fmaller; to it are added four teeth of wood, parallel to the blade, fixed and fecured in a proper manner, and intended to keep the corn together after being cut, fo that inftead of its falling in a confufed ftate, the reaper may lay it down in a regular and compact one. The fecond, or Auftrian fcythe, is fimilar to the former, except that the blade is larger; confequently the wooden teeth, of which there are five, are longer; the handle is alfo more flat, and rather crooked. Plate XLII.

In the *firft*, the handle *a b* (fee fig. 1.) is two Milanefe braffes (A), and nine inches and a half in length; the

(A) One hundred Milanefe *braffes* are equal to fifty-eight Englifh yards and a half.

the blade $b\,c$ is one brafs three inches and a half; the piece of wood in which the teeth are fixed, one brafs one inch and a half. In the *fecond*, the handle is two braffes, and feven inches long; the blade, one brafs eleven inches; the piece in which the teeth are fixed, eleven inches and a quarter. The proportions of the other parts may be conceived from the figure.

The difference in the conftruction of thefe two fcythes makes it requifite to ufe them in a different manner; but that will be better acquired in practice than by precept. Such of our countrymen as are accuftomed to the ufe of the common fcythe will very foon find out the moft convenient and advantageous manner of ufing thefe new kinds of fcythe, and of laying down the corn properly when cut.

It fhould, however, be obferved, that in mowing grafs the feet are kept almoft parallel to each other, whereas in reaping corn they fhould be kept upon a line, one behind the other, thrufting the right foot forward, and drawing the left towards it. This is neceffary, becaufe when grafs is mowed it is left to fall juft where it is cut; but when corn is cut, it is to be carried and laid in a proper manner againft that which is not yet cut, and which is at the left hand of the reaper; and if the feet were kept parallel to each other, the reaper would be obliged to extend and turn his body in a very inconvenient manner.

After having made public thefe obfervations, the fociety made farther experiments upon the fubject; in which it was found, that when, on account of very wet weather, the ftalks of the corn are bent down, the wooden teeth of the forementioned fcythes are apt to lay hold of fome ears, to the ftalks of which the iron does not reach, and confequently not being cut below, they are pulled fo that the grain is fcattered. This happens chiefly when the reapers, not being yet fufficiently accuftomed to that kind of fcythe, do not know how to adapt it to particular circumftances.

To remedy this inconvenience, it occurred to an ingenious blackfmith to add to the common fcythe a *gatherer* or *collector* made of cloth, as may be feen at fig. 2. where $a\,b\,c$ is a common fcythe; $c\,d\,m\,l\,o\,f\,n\,e$ is the gatherer; which at $c\,d\,e$ is compofed of a thin plate of iron, having at its extremity a hollow for receiving the point of the blade. At $e\,d$ are holes for fewing in the cloth, which is coarfe, light, and of low price; it is alfo fixed to two thick iron wires, of which the upper one is continued to f, where it terminates in a hole in the handle; the other is fixed to the back of the blade. The manner of fixing this gatherer to the blade of the fcythe will be better underftood by referring to fig. 3. which reprefents one of the irons which, by means of a fcrew, are faftened to the back of the fcythe. Thefe irons proceed from, and make part of, the upright irons $m\,n$, $l\,o$, which ferve to keep the gatherer extended.

This is a very fimple and cheap contrivance; but an attempt was made to render it ftill more fimple, by fubftituting for the gatherer two iron hoops, which are fhewn in fig. 2. by the dotted lines $h\,g$, $k\,i$, with a crofs piece p which connects them. Experience, however, has fhewn, that the gatherer is in general preferable to thefe hoops, as it does not leave an ear of corn behind.

RECTIFICATION OF ETHER, a procefs for depriving ether of its fulphureous acid (See CHEMISTRY-*Index* in this *Suppl.*) It has been ufual to add an alkali for this purpofe; but Dizé has found it much more advantageous to add a fubftance which might afford the requifite quantity of oxygen to convert the fulphureous into the fulphuric acid; in which ftate it is not difpofed to rife and come over. Various metallic oxides were tried, among which the black oxide of manganefe proved the beft and the cheapeft. His procefs is as follows:

The fulphureous acid contained in unrectified ether being neutralized with oxide of manganefe, the fluid is decanted into a pewter veffel of the capacity of fifty ounces, which is placed on a water bath. To this veffel a head and worm are adapted, the latter of which paffes through a refrigeratory conftantly fupplied with water in a ftream from below, which caufes the heated water to flow off above. The diftillation is then performed by raifing the bath to a temperature of 36° (113° Fahrenheit, if the decimal thermometer be here meant). The rectification by this treatment ufually requires a day to complete it. The flavour of the ether is of the beft kind, and the product about one fixth more than in the ufual method with retort and receiver. Dizé has practifed this method with fuccefs for three years.—*Journal de Phyfique, April*, 1798.

RECTIFICATION, in geometry, is the finding of a right line equal to a curve. The rectification of curves is a branch of the higher geometry, a branch in which the ufe of the inverfe method of fluxions is efpecially ufeful.

TURKEY-RED, *Levant-Red*, and *Adrianople-Red*, the names indifferently given to that beautiful red dye which diftinguifhes the cotton manufactured in the Ottoman empire, and at *Aftracan* in the dominions of Ruffia. We have two accounts of the procefs of communicating this dye to the ftuffs; one by Profeffor Pallas as he faw it practifed at Aftracan; the other in the 92d number of the *Annales de Chimie* by Citizen Felix. As every thing relating to ufeful manufactures is of general importance, we fhall give pretty copious extracts from both papers.

According to Dr Pallas, the dye-ftuffs employed at Aftracan are, madder, fumach, gall-nuts, alum, an inferior kind of foda, and fifh-oil. The procefs of dyeing is as follows:

The roots of the madder, when frefh gathered, are placed above each other in a ftove, or in a pit dug in vifcous earth which has been ftrongly heated. Earth is then thrown over the madder, and it muft fweat until the ftove or pit becomes cold; when the roots, the fecond or third day, are taken from it, and either fpread out or hung up to dry. When it is thoroughly dried in the fun, the madder is ground to a very fine powder, as are likewife the round leaves of the fumach (*rhus cotinus*). The fifh oil is boiled from the entrails of the fturgeon and other large fifhes; and the proof of its being proper for dyeing is, that when mixed with a lixivium of foda, it muft immediately affume a milky appearance. Should that not be the cafe, it cannot be ufed by the dyers.

The cotton to be dyed red is firft wafhed exceedingly clean in running water; and when the weather is clear, hung up on poles to dry. If it does not dry before the evening, it is taken into the houfe, on account of

Turkey-Red.

of the ſaline dews ſo remarkable in the country around Aſtracan, and again expoſed to the air next morning. When it is thoroughly dry it is laid in a tub, and fiſh-oil is poured over it till it is entirely covered. In this ſtate it muſt ſtand all night; but in the morning it is hung up on poles, and left there the whole day; and this proceſs is repeated for a week, ſo that the cotton lies ſeven nights in oil, and is expoſed ſeven days to the atmoſphere, that it may imbibe the oil, and free itſelf from all air. The yarn is then again carried to a ſtream, cleaned as much as poſſible, and hung up on poles to dry.

After this preparation a mordant is made of three materials, which muſt give the grounds of the red colour. The pulveriſed leaves of the ſumach are firſt boiled in copper kettles; and when their colouring matter has been ſufficiently extracted, ſome powdered galls are added, with which the liquor muſt be again boiled; and by theſe means it acquires a dark dirty colour. After it has been ſufficiently boiled the fire is taken from under the kettle, and alum put into the ſtill hot liquor, where it is ſoon diſſolved. The proportion of theſe three ingredients cannot be aſcertained, as the dyers vary that proportion at pleaſure. The powder of the ſumach leaves is meaſured into the kettle with laddles; the water is poured in according to a gauge, on which marks are made to ſhew how high the water muſt ſtand in the kettle to ſoak ſix, eight, ten, &c. puds of cotton yarn. The galls and alum are added in the quantity of five pounds to each pud of cotton. In a word, the whole mordant muſt be ſufficiently yellow, ſtrong, and of an aſtringent taſte.

As ſoon as the alum is diſſolved, no time muſt be loſt in order that the mordant may not be ſuffered to cool. The yarn is then put into hollow blocks of wood ſhaped like a mortar, into each of which ſuch a quantity of the mordant has been poured as may be ſufficient to moiſten the yarn without any of it being left. As ſoon as the workman throws the mordant into the mortar, he puts a quantity of the yarn into it, and preſſes it down with his hand till it becomes uniformly moiſtened, and the whole cotton yarn has ſtruck. By this it acquires only a pale yellow colour, which, however, is durable. It is then hung up on poles in the ſun to dry; again waſhed in the ſtream, and afterwards dried once more.

The next part of the proceſs is to prepare the madder dye. The madder, ground to a fine powder, is ſpread out in large troughs, and into each trough is poured a large cupful of ſheep's blood, which is the kind that can be procured with the greateſt facility by the dyers. The madder muſt be ſtrongly mixed in it by means of the hand, and then ſtand ſome hours in order to be thoroughly ſoaked by it. The liquor then aſſumes a dark red appearance, and the madder in boiling yields more dye.

After this proceſs water is made hot in large kettles, fixed in brickwork; and as ſoon as it is warm, the prepared red dye is put into it, in the proportion of a pound to every pound of cotton. The dye is then ſuffered to boil ſtrongly; and when it is enough, which may be tried on cotton threads, the fire is removed from under the kettle, and the prepared cotton is depoſited near it. The dyer places himſelf on the edge of the brickwork that incloſes the kettle; dips the cotton yarn, piece by piece, into the dye; turns it round backwards and forwards; preſſes it a little with his hands; and lays each piece, one after the other, in pails ſtanding ready for the purpoſe. As ſoon as all the cotton has received the firſt tint, it is hung up to dry; as the red, however, is ſtill too dull, the yarn, which has been already dyed once, and become dry, is put once more into the dyeing-kettle, and muſt be left there to ſeethe for three hours over a ſtrong fire; by which it acquires that beautiful dark red colour which is ſo much eſteemed in the Turky yarn. The yarn is now taken from the dye with ſticks; the ſuperfluous dye which adheres to it is ſhaken off; the hanks are put in order, and hung up, one after another, to dry. When it is thoroughly dry, it is waſhed in the pure ſtream, and again dried.

In the laſt place, the above-mentioned ſoda is diſſolved with boiling water in tubs deſtined for that purpoſe, and it is uſual at Aſtracan to allow 20 pounds of ſoda to 40 pounds of cotton, or half the weight. Large earthen jars, which are made in Perſia of very ſtrong clay, a yard and a half in height, almoſt five ſpans wide in the belly, and ending in a neck a ſpan and a half in diameter, incloſed by means of cement in brickwork over a fire-place, in ſuch a manner that the necks only appear, are filled with the dyed cotton yarn. The ley of diſſolved ſoda, which is blackiſh and very ſharp, is then poured over it till the jars be filled; and ſome clean rags are preſſed into their mouths, that the uppermoſt ſkains of yarn may not lie uncovered. A fire is then made in the fire-place below, and continued for 24 hours; and in the mean time the ſteam which ariſes from the jars is ſeen collected among the rags in red drops. By this boiling the dye is ſtill more heightened, and is made to ſtrike completely; every thing ſuperfluous is removed, and all the fat matter which ſtill adheres to the yarn is waſhed out. Nothing more is then neceſſary for completing the dye of the yarn but to rinſe it well ſeveral times in running water, and then to dry it.

Cotton cloth is dyed with madder at Aſtracan in the ſame manner; but many purſue a fraudulent proceſs, by dyeing with red wood, and then ſell their cloth as that which has been dyed in the proper manner.

The proceſſes followed in the Grecian manufactories in the Levant, as deſcribed by M. Felix, varies in ſome particulars from this. The firſt proceſs is that of cleaning the cotton: for which purpoſe three leys are employed; one of ſoda, another of aſhes, and a third of lime. The cotton is thrown into a tub, and moiſtened with the liquor of the three leys in equal quantities: it is then boiled in pure water, and waſhed in running water.

The ſecond bath given to the cotton is compoſed of ſoda and ſheep's dung diſſolved in water. To facilitate the ſolution, the ſoda and dung are pounded in a mortar. The proportions of theſe ingredients employed, are one occa of dung, ſix of ſoda, and forty of water; each occa being equal to about fifty ounces. When the ingredients are well mixed, the liquor expreſſed from them is ſtrained; and being poured into a tub, ſix occas of olive oil are added to it, and the whole is well ſtirred till it becomes of a whitiſh colour like milk. The cotton is then beſprinkled with this water; and when the ſkains are thoroughly moiſtened, they are wrung, Turkey-Red.

wrung, preſſed, and expoſed to dry. The ſame bath muſt be repeated three or four times, becauſe it is this liquor which renders the cotton more or leſs fit for receiving the dye. Each bath is given with the ſame liquor, and ought to continue five or ſix hours. It is to be obſerved that the cotton, after each bath, muſt be dried without being waſhed, as it ought not to be rinſed till after the laſt bath. The cotton is then as white as if it had been bleached in the fields.

It may be ſuppoſed that the dung is of no utility for fixing the colours; but this ſuppoſition would be raſh; for, as M. Felix obſerves, it is well known that this ſubſtance contains a great quantity of volatile alkali in a diſengaged ſtate, which has the property of giving a roſy hue to the red. It is therefore probable that it is to this ingredient that the red dyes of the Levant are indebted for their ſplendour and vivacity. This much, at any rate, is certain, that the Morocco leather of the Levant is prepared with dogs dung; becauſe it has been found that this dung is proper for heightening the colour of the lack.

The proceſs of galling, which follows the bath of dung, is performed by immerſing the cotton in a bath of warm water, in which five occas of pulveriſed gall-nuts have been boiled. This operation renders the cotton more fit for being ſaturated with the colour, and gives to the dye more body and ſtrength. After the galling comes aluming, which is performed twice, with an interval of two days, and which conſiſts in dipping the cotton into a bath of water in which five occas of alum have been infuſed, mixed with five occas of water alkaliſed by a ley of ſoda. The aluming muſt be performed with care, as it is this operation which makes the colouring particles combine beſt with the cotton, and which ſecures them in part from the deſtructive action of the air. When the ſecond aluming is finiſhed, the cotton is wrung; it is then preſſed, and put to ſoak in running water, after being incloſed in a bag of thin cloth.

The workmen then proceed to the dyeing. To compoſe the colours, they put in a kettle five occas of water, and 35 occas of a root which the Greeks call *ali-zari*, or painting colour, and which in Europe is known under the name of *madder*. The madder, after being pulveriſed, is moiſtened with one occa of ox or ſheep's blood. The blood ſtrengthens the colour, and the doſe is increaſed or leſſened according to the ſhade of colour required. An equal heat is maintained below the kettle, but not too violent; and when the liquor ferments, and begins to grow warm, the ſkains are then gradually immerſed before the liquor becomes too hot. They are then tied with packthread to ſmall rods placed croſſwiſe above the kettle for that purpoſe; and when the liquor boils well, and in an uniform manner, the rods from which the ſkains were ſuſpended are removed, and the cotton is ſuffered to fall into the kettle, where it muſt remain till two-thirds of the water is evaporated. When one-third only of the liquor remains, the cotton is taken out and waſhed in pure water.

The dye is afterwards brought to perfection by means of a bath alkaliſed with ſoda. This manipulation is the moſt difficult and the moſt delicate of the whole, becauſe it is that which gives the colour its tone. The cotton is thrown into this new bath, and made to boil over a ſteady fire till the colour aſſumes the required tint. The whole art conſiſts in catching the proper degree: a careful workman, therefore, muſt watch with the utmoſt attention for the moment when it is neceſſary to take out the cotton; and he will rather burn his hand than miſs that opportunity.

Turkey-Red ‖ Reflector.

It appears that this bath, which the Greeks think of ſo much importance, might be ſupplied by a ley of ſoap; and it is probable that ſaponaceous water would give the colour more brightneſs and purity.

M. Felix ſeems doubtful whether the ali-zari of the Greeks be the ſame plant with the European madder. If it be, its ſuperiority muſt ariſe from the mode in which it is cultivated, and the method employed to dry it. The ali-zari is not collected till the fifth or ſixth year of its growth, when it has acquired its full ſtrength; and as it is the woody part of the roots which affords the greateſt quantity of colouring particles, this muſt give it an obvious ſuperiority over madder, which is collected before it has arrived at maturity. The mode of deſiccation contributes alſo, in the opinion of our author, to improve the quality of the ali-zari. The Levantines dry it in the open air; and this operation is eaſy in a country where great dryneſs prevails in the atmoſphere, while in our damp climates we are obliged to dry the madder by ſtoves. Hence it happens that the ſmoke, which mixes itſelf with the cold air, and penetrates the roots, impregnates them with fuliginous particles, which alter the colouring ſubſtance; an accident which does not take place when the madder is dried without the aſſiſtance of fire.

For the philoſophical principles of theſe proceſſes of dyeing, ſee *Animal and Vegetable* SUBSTANCES in this *Supplement*.

REDINTEGRATION, is the taking or finding the integral or fluent again from the fluxion. See FLUXIONS, *Encycl.*

REFLECTOR FOR A LIGHT-HOUSE, is compoſed of a number of ſquare plane glaſs mirrors, ſimilar to thoſe with which Archimedes is ſaid to have ſet fire to the Roman fleet at the ſiege of Syracuſe (See BURNING, *Encycl.*) Each of theſe mirrors is about an inch ſquare; and they are all diſpoſed cloſe to each other in the concave of a parabolic ſegment, formed of ſtucco or any other proper bed. Stucco has been found to anſwer the purpoſe beſt; and is accordingly employed in all the reflectors of the light-houſes erected by Mr Thomas Smith tinplate worker, Edinburgh, at the expence, and by the authority, of government. This ingenious and modeſt man ſeems to have conceived the idea of illuminating light-houſes by means of lamps and reflectors inſtead of coal-fires, without knowing that ſomething of the ſame kind had been long uſed in France; he has therefore all the merit of an inventor, and what he invented he has carried to a high degree of perfection.

His parabolic moulds are from three to five or ſix feet in diameter; and in the centre or apex of each is placed a long ſhallow lamp of tin-plate, filled with whale oil. In each lamp are ſix cotton wicks, almoſt contiguous to each other, which are ſo diſpoſed as to burn without trimming for about ſix hours. The light of theſe is reflected from each mirror ſpread over the concave ſurface, and is thus multiplied, as it were, by the number of mirrors. The ſtucco moulding is covered on the back with tin-plate, from which a tube, immediately over the lamp, proceeds to the roof of the

 light

light room, and serves as a funnel, through which the smoke escapes without sullying the faces of the mirrors. The light-room is a cupola or lantern of from eight to twelve sides, composed entirely of glass, fixed in cast-iron frames or sashes, and roofed with copper. On circular benches passing round the inside of this lantern, at about eighteen inches from the glass frames, are placed the reflectors with their lamps, so as that the concave surfaces of two or three of the reflectors front every point of the compass, and throw a blaze of light in all directions. In the roof immediately over the centre of the room is a hole, through which pass all the funnels already mentioned, and which serves likewise to admit fresh air to the lamps. This light room is firmly fixed on the top of a round tower so as to be immoveable by the weather; and the number of the reflectors, and the height of the tower, are less or greater according as it is the intention that the light should be seen at a less or a greater distance.

A man judging from mere theory would be very apt to condemn light-houses of this kind; because the firmest building shakes in a violent storm, and because such shaking, he might think, would sometimes throw the whole rays of light into the air, and thus mislead the bewildered seaman. This opinion, we know, was actually entertained of them by one of the profoundest philosophers and most scientific mechanicians of the age. Experience, however, has convinced him, as well as the public at large, that such apprehensions are groundless, and that light-houses with lamps and reflectors are, in every point of view, preferable to those with fires burning in the open air. They are supported at much less expence; their light is more brilliant, and seen at a greater distance, whilst it can never be obscured by smoke, or beaten down on the lee-side by a violent gust of wind; and what is perhaps of still greater importance, the reflectors with their lamps may be so variously placed, that, as Mr Smith observes, one light-house cannot be mistaken for another. If we add to all this, that the lamps do not stand in need of trimming so often as open fires require fuel, and that the light man is never exposed either to cold or to wet by attending to his duty, we must be convinced that light-houses with reflectors are much less liable to be neglected in stormy weather than those with open fires, and that this circumstance alone would be enough to give the former a preference, almost incalculable, over the latter.

It has been proposed to make the concave surface of the parabola one speculum of metal, instead of covering it over with a multitude of plain glass mirrors; or to diminish the size of each mirror, if they are to be retained in preference to the metallic speculum. To every man who has but dipped into the science of optics, it must be obvious, that either of these alterations would be wrong. The brightest metal does not reflect such a quantity of light as well foliated clear glass; and were the size of the mirrors to be diminished, the number of joinings would be increased, in each of which some light is lost, not merely in the seam, but from its being almost impossible to foliate glass perfectly at its edge.

REFLEXITY, a word employed by Mr Brougham to denote a property of light which causes the different rays to be acted upon by bodies, and to begin to be refracted, reflected, inflected, and deflected, at different distances. This property follows the same law that the other optical properties of light follow: the red ray having most reflexity, and the violet least (See *Philosophical Transactions*, 1797, p. 360.) Mr Brougham has denoted this property by the three words, *refrangity*, *reflexity*, and *flexity*; but as the power is the same there is no occasion for different names. Some philosophers have refused to admit this as a new property; we have not verified it by experiment.

REFRACTION OF ALTITUDE, is the arc or portion of a vertical circle, by which the altitude of a star is increased by the refraction of light.

Refraction of Ascension and Descension, is an arc of the equator, by which the ascension and descension of a star, whether right or oblique, is increased or diminished by the refraction.

Refraction of Declination, is an arc of a circle of declination, by which the declination of a star is increased or diminished by refraction.

Refraction of Latitude, is an arc of a circle of latitude, by which the latitude of a star is increased or diminished by the refraction.

Refraction of Longitude, is an arc of the ecliptic, by which the longitude of a star is increased or diminished by means of the refraction.

Terrestrial Refraction, is that by which terrestrial objects appear to be raised higher than they really are, in observing their altitudes. The quantity of this refraction is estimated by Dr Maskelyne at one tenth; by Le Gendre at one-fourteenth; by De Lambre at one-eleventh; and by others at a twelfth of the distance of the object observed, expressed in degrees of a great circle. But it is obvious that there can be no fixed quantity of this refraction, since it depends upon the state of the atmosphere, which is extremely variable. Hence some very singular effects of it are related, of which the following is worthy of notice. It is taken from the Philosophical Transactions of London 1798; being an extract of a letter, dated Hastings, August 1. 1797.

"On Wednesday, July 26, about five o'clock in the afternoon, while I was sitting in my dining room at this place, which is situated upon the Parade, close to the sea shore, nearly fronting the south, my attention was excited by a number of people running down to the sea-side. Upon enquiring the reason, I was informed that the coast of France was plainly to be distinguished by the naked eye. I immediately went down to the shore, and was surprised to find that, even without the assistance of a telescope, I could very plainly see the cliffs on the opposite coast; which, at the nearest part, are between 40 and 50 miles distant, and are not to be discerned, from that low situation, by the aid of the best glasses. They appeared to be only a few miles off, and seemed to extend for some leagues along the coast. I pursued my walk along the shore eastward, close to the water's edge, conversing with the sailors and fishermen upon the subject. They at first could not be persuaded of the reality of the appearance; but they soon became so thoroughly convinced, by the cliffs gradually appearing more elevated, and approaching nearer, as it were, that they pointed out and named to me the different places they had been accustomed to visit; such as the Bay, the Old Head or Man, the Windmill, &c. at Boulogne; St Vallery, and other places on the coast of Picardy; which they afterwards confirmed when they

they viewed them through their telefcopes. Their obfervations were, that the places appeared as near as if they were failing, at a fmall diftance, into the harbours."

The writer of this extract was W. Latham, Efq; F. R. S. and A. S. who adds, that the day was extremely hot, that it was high water at Haftings about two o'clock P. M. and that not a breath of wind was ftirring the whole day.

REGIS (Peter Sylvain), a French philofopher, and great propagator of Cartefianifm, was born in Agenois 1632. He cultivated the languages and philofophy under the Jefuits at Cahors, and afterwards divinity in the univerfity of that town, being defigned for the church. He made fo uncommon a progrefs, that at the end of four years he was offered a doctor's degree without the ufual charges; but he did not think it became him to accept of it till he had ftudied alfo in the Sorbonne at Paris. He went thither, but was foon difgufted with theology; and as the philofophy of Des Cartes began at that time to make a noife through the lectures of Rohault, he conceived a tafte for it, and gave himfelf up entirely to it. He frequented thefe lectures; and becoming an adept, went to Toulonfe in 1665, and read lectures in it himfelf. Having fine parts, a clear and fluent manner, and a happy way of making himfelf underftood, he drew all forts of people; the magiftrates, the learned, the ecclefiaftics, and the very women, who now all affected to abjure the ancient philofophy. In 1680 he returned to Paris; when the concourfe about him was fuch, that the fticklers for Peripateticifm began to be alarmed. They applied to the Archbifhop of Paris, who thought it expedient, in the name of the king, to put a ftop to the lectures; which accordingly were difcontinued for feveral months. The whole life of Regis was fpent in propagating the new philofophy. In 1690 he publifhed a formal fyftem of it, containing logic, metaphyfics, phyfics, and morals, in 3 vols 4to, and written in French. It was reprinted the year after at Amfterdam, with the addition of a difcourfe upon ancient and modern philofophy. He wrote afterwards feveral pieces in defence of his fyftem; in which he had difputes with M. Huet, Du Hamel, Malebranche, and others. His works, though abounding with ingenuity and learning, have been difregarded, in confequence of the great difcoveries and advancement in philofophic knowledge that have been fince made. He died in 1707. He had been chofen member of the academy of fciences in 1699*.

* *Biog. Dict.* new edit.

REGULAR BODY, called alfo *Platonic Body*, is a body or folid comprehended by like, equal, and regular plane figures, and whofe folid angles are all equal.

The plane figures by which the folid is contained are the faces of the folid; and the fides of the plane figures are the edges, or linear fides of the folid

There are only five regular folids, viz.

The tetrahedron, or regular triangular pyramid, having four triangular faces;

The hexahedron, or cube, having fix fquare faces;

The octahedron, having eight triangular faces;

The dodecahedron, having twelve pentagonal faces;

The icofahedron, having twenty triangular faces.

Befides thefe five, there can be no other regular bodies in nature. See PLATONIC *Body*, Suppl.

REGULUS, in aftronomy, a ftar of the firft magnitude, in the conftellation Leo; called alfo, from its fituation, *Cor Leonis*, or the *Lion's Heart*; by the Arabs, *Albabor*; and by the Chaldeans, *Kalbeleced*, or *Karbeleceid*; from an opinion of its influencing the affairs of the heavens.

REID (Thomas, D. D.), fo well known to the public by his moral and metaphyfical writings, was the fon of the Rev. Lewis Reid, minifter of the parifh of Strachan, in the county of Kincardine, North Britain. His mother was the daughter of David Gregory, Efq; of Kinardie, of whom fome account has been given in this *Supplement*, and fifter to David, James, and Charles Gregories, who were at the fame time profeffors of aftronomy, or mathematics, in the univerfities of Oxford, Edinburgh, and St Andrews.

He was born at the parfonage-houfe of Strachan in April 1710, and received the rudiments of his education at the parifh fchool of Kincardine-oniel. At that period the parochial fchools of Scotland were very fuperior to what they are now; and young men went from them to the univerfity well furnifhed with philological learning. The progrefs of young Reid muft have been rapid; for he was removed from fchool to the Marifchal College, Aberdeen, when not more than twelve years of age; and we have never heard that he was admitted into the univerfity before he was qualified to profit by the lectures of the profeffors. On the contrary, he foon difplayed the genius of his mother's family, and fhone confpicuous among the ftudents of mathematics in a college where that fcience has been at all times cultivated with ardour and fuccefs.

After the ufual courfe of four years employed in the ftudy of Latin, Greek, Mathematics, and Philofophy, he probably took his degree of M. A. which at that period, and for a long time fubfequent to it, was the univerfal practice in the univerfity of Aberdeen, and then commenced the ftudy of theology. In due time he was licenfed to preach the gofpel according to the forms of the church of Scotland; but continued to refide for fome years in Aberdeen, cultivating his favourite fcience, mathematics.

The mathematical chair in Marifchal College was then filled by Mr John Stuart, a man of great eminence in his profeffion; but who, like many other profound mathematicians, was not happy in his mode of communicating fcience, at leaft to the duller part of his pupils. Mr Reid occafionally read lectures for the profeffor; and a friend of our's, by no means dull, has often been heard to exprefs great fatisfaction that Mr Stuart was kept a whole winter from the fchools, when he was a ftudent, and that the clafs was taught by Mr Reid. "Had it not been for this circumftance (faid he) I fhould never have underftood more of mathematics than the firft fix books of Euclid's elements; but Mr Reid had the faculty of making every thing intelligible to the ftudents which he clearly apprehended himfelf."

He could not, however, fpend his life in the ftudy of mathematics, and in reading barren lectures for other men. He had been educated for the church; and it was in the church only that he had the profpect of gaining a livelihood. He was accordingly prefented, we know not in what year, to the church of *New Machar* in Aberdeenfhire, at the time when the good people of Scotland were very far from being reconciled to the rights of patronage; and the confequence was, that

that his fettlement met with much popular oppofition. Even a little riot took place in the church at his ordination; but he foon gained the affections of his flock by his good fenfe, his acknowledged worth, and his unwearied attention to all their wants, which he was ever ready to relieve to the utmoft extent of his abilities. So deeply rooted indeed was their regard for him at laft, that, though it is now almoft half a century fince his relation to the parifh of New Machar ceafed, his memory continues to be revered in that parifh even at the prefent day; and the following anecdote evinces that it is not revered without reafon.

A man who, from being in decent circumftances, and a member of the kirk feffion (See PRESBYTERIANS, *Encycl.*), when Dr Reid was minifter, had become, in his old age, poor and infirm, obferved to the then minifter of the parifh, that if he were able to go to Glafgow, and make his cafe known to his old friend and paftor, he was fure that he would get fomething done for him. This obfervation was reported to the Doctor, who inftantly recollected the man, though, in all probability, he had not thought of him for thirty years; and he fettled upon him an annual penfion of ten pounds, which was punctually paid as long as they both lived. The pride of fcience had not from the mind of this great man eradicated the amiable fympathies of humanity, nor had his philofophic fame made him overlook the unafpiring duties of the Chriftian paftor.

In the year 1751, about the beginning of the feffion or annual term, one of the profeffors of philofophy in King's College, Aberdeen, died; and his death being unexpected, prefented to the other members of that learned body fome difficulty in carrying on the ufual courfe of education for that year. At this our readers will not be furprifed, when they reflect on the modeon which fcience was taught in that univerfity; for he who could with propriety be placed in the vacant chair, muft have been qualified, without much previous preparation, to read lectures on LOGIC, ONTOLOGY, PNEUMATICS, MORALS, POLITICS, MATHEMATICS, and NATURAL PHILOSOPHY (See GERARD, in this *Suppl.*) In fuch a place as Aberdeen, it is hardly to be fuppofed that there was a fingle man unemployed, fo completely mafter of all thefe branches of fcience, as to take up the clafs where it was dropt by the deceafed profeffor, and carry it fuccefsfully through that fcience, whatever it might be, in which, at his death, he chanced to be lecturing. It occurred, however, to the principal, and fome of the profeffors, that the minifter of New Machar was fully equal to the tafk; and the late Dr John Gregory, then profeffor of medicine, and the Rev. Dr Macleod, the prefent fubprincipal of King's College, were deputed to vifit Mr Reid, and requeft his immediate acceptance of the vacant profefforfhip. He yielded to the requeft not without fome hefitation, and was admitted profeffor of philofophy on the 22d of November.

He was now in the very fituation for which Nature feemed to have intended him. He had not only an opportunity, but it was his duty to cultivate the fcience to which his attachment was fo ftrong; and the duties of his office made him turn his attention more clofely than he had hitherto done to another fcience, in which he was deftined to make a more confpicuous figure than he ever made even in his favourite mathematics.

It was during his profefforfhip in the univerfity of Aberdeen that he wrote his "Effay on Quantity," which was publifhed in the 45th volume of the Philofophical Tranfactions, and is perhaps the fineft fpecimen of metaphyfical mathematics, if we may ufe fuch an expreffion, that is extant in our own or in any other language (See QUANTITY, *Encycl.*). It was during the fame period that he publifhed his "Inquiry into the Human Mind on the Principles of Common Senfe;" a work of unqueftionable merit, which has contributed more than any other work whatever to give a rational turn to metaphyfical fpeculations. It was about this period that the degree of D. D. was conferred upon him by his mother-college.

The well-earned fame of Dr Reid attracted the attention of the univerfity of Glafgow to him as the fitteft perfon to fucceed the celebrated Dr Adam Smith; and he was admitted profeffor of moral philofophy in that univerfity on the 11th of June 1764. There his attention was not diftracted by a multitude of fciences, which it was his duty to teach; and he had leifure to improve his metaphyfical fyftem, though he continued through life to amufe himfelf occafionally with mathematical fpeculations.

In the year 1773 appeared, in Lord Kames's "Sketches of the Hiftory of Man, a brief Account of Ariftotle's Logic; with remarks by Dr Reid." It would feem that he had entered upon this tafk rather reluctantly, and merely in compliance with the folicitations of his friend, the author of the Sketches. "In attempting (fays he) to give fome account of the analytics, and of the topics of Ariftotle, ingenuity requires me to confefs, that though I have often purpofed to read the whole with care, and to underftand what is intelligible, yet my courage and patience always failed before I had done. Why fhould I throw away fo much time and painful attention upon a thing of fo little ufe? If I had lived in thofe ages when the knowledge of Ariftotle's Organon intitled a man to the higheft rank in philofophy, ambition might have induced me to employ upon it fome years of painful ftudy; and lefs, I conceive, would not be fufficient. Such reflections as thefe always got the better of my refolution, when the firft ardour began to cool. All I can fay is, that I have read fome parts of the different books with care, fome flightly, and fome perhaps not all. I have glanced over the whole often; and when any thing attracted my attention, have dipped into it till my appetite was fatisfied."

Notwithftanding this modeft acknowledgment, we are not fure that any one of Dr Reid's publications does him greater honour than his very perfpicuous view of this ftupendous fyftem. Having ourfelves occafionally looked into the writings of Ariftotle, we fhould not hefitate to fay, that it is by much the beft analyfis of thefe writings that we have any where met with, even though we could not corroborate our own opinion by that of other men much more converfant than we are with the oracular language of the Stagyrite. But when it is known that the late Dr Doig of Stirling, to whom Greek was as familiar as his mother tongue, and an equally learned Doctor of Oxford, who has been reading Ariftotle ever fince he was fourteen years of age, agreed in opinion, that a more accurate view of his logic could not be given in the fame compafs than had been

been given by Dr Reid, we may furely affirm, with fome degree of confidence, that this fmall work adds much to the fame of our celebrated countryman.

Though Dr Reid's health continued good, and his mental faculties unimpaired, till a very fhort time before his death, he ceafed for fome years to read lectures from his profeffional chair, employing that time in preparations for eternity, and in fitting his lectures for the prefs. Thefe were publifhed in two volumes 4to: the firft in 1785, under the title of "Effays on the Intellectual Powers of Man," dedicated to his friends Dr Gregory and Profeffor Stewart, both of the univerfity of Edinburgh; and the fecond in 1788, under the title of "Effays on the Active Powers of Man," without any dedication or preface. He continued to enjoy the fame acquired by this work, as well as the affection of his friends and the reverence of the public, for eight years, dying at Glafgow in the end of September, or the beginning of October 1796, in the 87th year of his age. He had been married, and he left behind him one daughter.

To do juftice to the biography of fuch a man as this, we fhould here attempt to draw his intellectual character, and to appreciate the merits of his works; but to perform this tafk in a manner at all worthy of him, or we hope of ourfelves, would require more room than our limits permit us to allot to any article of the kind; and our readers will be pleafed to learn, that they may confidently expect an account of his life, with a critique on his works, by a man better qualified to do juftice to both, than the writer of this fhort fketch pretends to be. His works are in the hands of the fpeculative public; and by that public will be duly valued, as long as found fenfe fhall be preferred to impious jargon. How long that may be, God only knows; but if any thing can guard the minds of our youth againft that fophiftry of which the object is to attribute real agency to material fluids, and to reprefent the elective attractions of chemiftry as perfectly fimilar to human volitions, it will be the unbiaffed ftudy of Dr Reid's "Effays on the Intellectual and Active Powers of Man." They will there find metaphyfics divefted of myftery, and the profoundeft fpeculations rendered intelligible by the conftant ufe of words in one determined fenfe. We think, indeed, that in this confifts the Doctor's chief merit; for, except when treating of our notions of power, he feems not to have added much to what certainly *may be* found in the writings of Locke.

Let not our readers fuppofe, that by this obfervation we wifh to detract in the fmalleft degree from our author's fame, or to leffen him by comparifon with the Englifh philofopher. If on mere topics of fpeculative fcience, he appears to us to have thought as Locke thought, it is on the other hand certain, that the greater part of Locke's doctrines may be gleaned from the logical and metaphyfical writings of Bacon, Hobbes, and Des Cartes. Nor need this furprife any one; for he who reflects a moment on the fubject, muft perceive that fuch a coincidence of thought in metaphyfical fcience is among men of eminence almoft inevitable. Of mind and its powers—the fubject of that fcience—we neither know, nor can know any thing, but by patiently attending to the operations of our own minds, when we fee, hear, feel, think, reafon, and will, &c.: and it is obvious, that every man who is capable of fuch patient attention, and does not labour under the bias of fome prejudice, muft view thefe operations in the fame way. The great fuperiority of Dr Reid over his predeceffors, in this department of fcience, appears to have been this, that he apprehended the operations of his own mind with a clearnefs, which gave to his language a precifion and perfpicuity which the language of Locke certainly does not poffefs.

In the Effay on the Human Underftanding, the term *idea* fometimes fignifies a material fubftance, fometimes the qualities of that fubftance, fometimes the conception of thefe qualities, fometimes the power or faculty of the mind by which we conceive a thing, fometimes a perception of fenfe, and fometimes an intellectual notion. Hence the ambiguity of terms which runs thro' the whole of that immortal work, has furnifhed both the author's friends and his enemies with an opportunity of attributing to him pernicious doctrines, which we are perfuaded he did not maintain, and which, we think, a patient analyfis of the effay muft *convince every man* that he did not maintain. From this ambiguity the writings of Dr Reid are perfectly free. His doctrines, whether well or ill-founded, can never be mifunderftood by him who is defirous to underftand them; and he who knows how much perfpicuity of ftyle depends upon accuracy of thinking, will not deem us enemies to his fame for having faid that his chief merit confifts in the precifion of his language.

He has been much cenfured by fome, and much applauded by others, for introducing the phrafe *common fenfe* into fpeculative philofophy, as the proper name of that faculty of the mind by which we apprehend firft truths: but he is on this account entitled neither to praife nor to cenfure. He adopted the phrafe from others; and has proved, by the moft unexceptionable authorities, both ancient and modern, that it may with great propriety be ufed as he has ufed it. Whether the adopting of it into works of fcience was neceffary, is another queftion, on which we have given our opinion elfewhere; it is fufficient in this place to vindicate his ufe of it, efpecially in his latter works, from ambiguity.

Candour obliges us to acknowledge, that he has advanced fome doctrines which we cannot admit as true. Though not in general partial to Locke, he has adopted his notions refpecting our power of abftraction with hardly any other variation than the fubftituting of the term *conceptions* for Locke's favourite phrafe *ideas*. He has likewife endeavoured to prove, that we may diftinctly conceive what cannot poffibly exift. Thefe miftakes, for fuch they appear to us, we have pointed out elfewhere (See Metaphysics, Part I. Chapt. iii. and iv. *Encycl.*); but they are infinitely more than counterbalanced by his clear, accurate, and fatisfactory difquifitions on our notions of active power. Had Dr Reid never written a fentence but the effay which treats of this delicate and important fubject, he would have been entitled to a place in the very firft rank of ufeful metaphyficians; for, previous to the appearance of his works, we had nothing written directly on *power* but contradictory and unintelligible jargon. We recommend the ferious perufal of this effay, the firft in his fecond volume, to fuch of our readers as fancy that they diftinctly conceive the powers of chemical agents, and that intelligence and volition may refult from any mechanical organization, Reiske. organization, or any combination whatever of matter and motion.

REISKE (John James), a most profound scholar and sagacious critic, was born in 1706 at a small town of the duchy of Anhalt. After struggling with some difficulties in his school education, in which, however, he, by perseverance, obtained considerable advantages, he went, in 1733, to Leipsic; where he continued, for the sake of study, five years. Here he accomplished himself in Arabic, and translated and published a book from that language. In order to prosecute his study of Arabic with greater effect, he travelled on foot, and with many difficulties, to Leyden. Here he was employed in arranging the Arabic manuscripts, for which, however, he received a very scanty compensation; and here also he translated from the German and French, into Latin, various essays set him by Dorville, whom he had visited in his journey, and who afterwards inserted these papers in the *Miscellanea Critica*. Dorville was so well pleased with his skill and diligence, that he employed him in more important concerns. At his desire, Reiske translated the whole of the Chariton from the Greek, and the Geography of Abulfeda from the Arabic, into Latin. At Leyden he continued for the space of eight years; where a storm of jealousy and calumny, excited against him by the younger Burman, finally induced him to change his residence. This was principally owing to the freedom he used with respect to the edition of Petronius, edited by the younger Burman at Leyden; however, before he quitted it, he took the degree of doctor of physic, which was given him in a manner which did him the highest honour. He then visited different parts of Germany, till he at length settled at Leipsic a second time. Here, for twelve years, notwithstanding he was made professor of Arabic, he experienced all the inconveniences of poverty, and was obliged to undergo a great deal of drudgery for booksellers, and the editors of periodical publications, to procure a subsistence; at this period, in particular, the *Acta Eruditorum* were greatly indebted to him. Amidst all these hardships, however, he found opportunity to write, and to publish, his *Animadversiones in Auctores Græcos*, in five volumes; a work of extraordinary learning and merit. In 1758, by the death of Haltausius, he obtained a situation at once honourable and lucrative, which placed him above want, and enabled him to follow his favourite pursuits at ease. He was made rector of the academy at Leipsic, in which office he continued till the time of his death. In 1764, he married Ernestina Christina Muller, a woman of wonderful attainments, whose knowledge was hardly inferior to his own, and particularly in Greek literature. She assisted him in all his literary labours, and especially in his immortal work of the "Edition of the Greek Orators." Thus, in the manner most grateful to himself, Reiske consumed the remainder of his life, which continued till 1774, when he died possessed of the highest reputation. The number of works which he superintended and published is very great; but it will be sufficient to name those which are most sought after and esteemed. These are, the "Remarks upon Greek Authors," before mentioned. An "Edition of the Greek Orators," in 12 vols 8vo, which was finished by his widow. "Dionysius Halicarnassensis," in 7 vols. "Plutarch's Works," in 9 vols. "Theocritus, &c. &c." This John James Reiske must not be confounded with *John Reiske*, rector of the college of Wolfenbuttel, who was also a learned man, and published various works *.

Remonstrants || Republicans.

REMONSTRANTS, in church history, a title given to the ARMINIANS (See that article, *Encycl.*) by reason of the remonstrance which, in 1610, they made to the States of Holland, against the sentence of the synod of Dort, which condemned them as heretics. Episcopius and Grotius were at the head of the *Remonstrants*, whose principles were first openly patronised in England by Archbishop Laud. In Holland, the patrons of Calvinism presented an address in opposition to the remonstrance of the Arminians, and called it a counter-remonstrance. Hence the Dutch Calvinists were termed *Counter Remonstrants*. Much controversy was carried on by these rival sects, which, on the side of the Calvinists, was extremely illiberal.

* *Biog. Dict.* new edit.

REMORA, or SUCKING FISH, a species of ECHENEIS (See *Encycl.*), M. Vaillant found, upon different parts of his enormous *ray* (See RAJA in this *Suppl.*) about twenty small sucking fish, or *remoras*, fastened so firmly that they did not drop off when he was hoisted on board. Some naturalists have said, that the head of the sucking fish is viscous on the lower part, and furnished with rough points similar to the teeth of a file; and, according to them, it is by means of these two qualities, its roughness and viscosity, that it is enabled to adhere to other fish.

"Figure to yourself (says one of them) a row of nineteen sharp-edged and dentated laminæ, placed crosswise, and issuing immediately from the rim of the lower jaw, and you will have a just idea of the part with which the remora makes itself fast."

This description (says Vaillant) is exact as far as relates to the figure and number of the dentated laminæ; but it places them on the lower part of the head, whereas they are, in reality, on the upper. Accordingly, when the remora fixes itself, it is obliged to turn upon its back, with its belly upward.

If the two white fish, however, that posted themselves on the arms of the *ray*, and served him as pilots, be of the remora species, as he is inclined to think, the laminæ by which that variety adheres to other fishes must be on the lower part of the body, since the two pilots continued in their natural position, and had no occasion to turn over to fix themselves at their post.

REPETEND, in arithmetic, denotes that part of an infinite decimal fraction, which is continually repeated *ad infinitum*. Thus in the numbers $2{\cdot}13\ 13\ 13$, &c, the figures 13 are the repetend, and marked thus $\dot{1}\dot{3}$.

REPUBLICANS, the name given by Vaillant, with some propriety, to a kind of birds which were observed in South Africa, both by him and Paterson, to inhabit apparently the same enormous nest. Cutting one of these nests in pieces with a hatchet, he perceived that the principal and fundamental piece consisted of a mass of strong coarse grass (called by the Hottentots *Boshmen's grass*), without any mixture, but so compact and firmly knit together as to be impenetrable to the rain. This nucleus is the commencement of the structure; and each bird builds and applies to it its particular nest. But these cells are formed only beneath and around the mass; the upper surface remains void, without, however, being useless; for, as it has a projecting

Republicans, Residual.

jecting rim, and is a little inclined, it ferves to let the water run off, and preferves each dwelling from the rain. Figure to yourfelf a huge irregular mafs, the fummit forming a kind of roof, and all the other parts of the furface completely covered with cells fqueezed one againft another, and you will have a tolerably accurate idea of thefe fingular edifices.

Each cell is three or four inches in diameter, which is fufficient for the bird. But as they are all in contact with one another through the greater part of the furface of the mafs, they appear to the eye to form but one building, and are diftinguifhable from each other only by a little external aperture, which ferves as an entrance to the neft; and even this is fometimes common to three different nefts, one of which is fituated at the bottom, and the other two at the fides.

The neft which he examined contained 320 inhabited cells, which, fuppofing a male and female to each, announce a fociety of 640 individuals. Such a calculation, however, would not be exact; for whenever our author fired at a flock of thefe birds, he always killed four times as many females as males. "For the reft (fays he), thefe birds have nothing very remarkable in their plumage. It is an uniform brown grey, diverfified by a few black fpots on the fides, and a large patch of the fame colour on the throat. The male is a little larger than the female; in other refpects they exactly refemble each other."

RESIDUAL ANALYSIS, a calculus propofed by the inventor, Mr Landen, as a fubftitute for the method of fluxions. The object of this fubftitution was to avoid introducing the idea of motion, and of quantities infinitely or indefinitely fmall, into mathematical inveftigation. The refidual analyfis accordingly proceeds, by taking the difference of the fame function of a variable quantity in two different ftates of that quantity, and expreffing the relation of this difference to the difference between the two ftates of the faid variable quantity itfelf. This relation being firft expreffed generally, is then confidered in the cafe when the difference of the two ftates of the variable quantity is $= 0$; and by that means it is evident, that the fame thing is done as when the fluxion of a function of a variable quantity is affigned by the ordinary methods.

The evolution of the functions, confidered in this very general view, requires the affiftance of a new theorem, difcovered by Mr Landen, and remarkable for its fimplicity, as well as its great extent. It is, that if x and v are any two variable quantities, $\frac{x^{\frac{m}{n}} - v^{\frac{m}{n}}}{x - v}$

$$= x^{\frac{m}{n}-1} \times \frac{1 + \frac{v}{x} + \frac{v^2}{x^2} + \frac{v^3}{x^3} + \cdots (m)}{1 + \left(\frac{v}{x}\right)^{\frac{m}{n}} + \left(\frac{v}{x}\right)^{\frac{2m}{n}} + \left(\frac{v}{x}\right)^{\frac{3m}{n}} \cdots (n)}$$

where m and n are any integer numbers.

This theorem is the bafis of the calculus; and from the expreffions $x^{\frac{m}{n}} - v^{\frac{m}{n}}$, and $x - v$ having the form of what algebraifts call *refiduals*, the ingenious inventor gave to his whole method the name of the *refidual analyfis*.

Refidual, Revivification.

The firft account of this method was publifhed by Mr Landen in 1758, under the title of a *Difcourfe concerning the Refidual Analyfis*. The firft book of the Refidual Analyfis itfelf was publifhed in 1764; and contained an explanation of the principles of the new calculus, with its application to feveral of the moft confiderable problems belonging to the direct method of fluxions. The fecond book was intended to give the folution of many of the moft difficult problems that belong to the inverfe method of fluxions, or to the integral calculus; but it has never been publifhed: a circumftance which every one, who has taken the trouble to ftudy the firft part of the work, will very much regret.

If we eftimate the value of the refidual analyfis from the genius, profound knowledge, and extenfive views required to the difcovery of it, it will rank high among works of invention: but if, on the other hand, we eftimate its value by its real practical utility, as an inftrument of inveftigation, we muft rate it much lower. When compared with the fluxionary calculus, which it was intended to fuperfede, its principles, though in appearance more rigorous, are much lefs eafily apprehended, much lefs luminous, and lefs direct in their application: and therefore, as a means of extending the bounds of mathematical fcience, it muft ever be regarded as vaftly inferior to the latter (A.)

RETICULA, or RETICULE, in aftronomy, a contrivance for meafuring very nicely the quantity of eclipfes, &c. This inftrument, introduced fome years fince by the Paris Academy of Sciences, is a little frame, confifting of 13 fine filken threads, parallel to, and equidiftant from, each other, placed in the focus of object glaffes of telefcopes; that is, in the place where the image of the luminary is painted in its full extent. Confequently the diameter of the fun or moon is thus feen divided into 12 equal parts or digits: fo that, to find the quantity of the eclipfe, there is nothing to do but to number the parts that are dark, or that are luminous. As a fquare reticule is only proper for the diameter of the luminary, not for the circumference of it, it is fometimes made circular, by drawing fix concentric equidiftant circles, which reprefents the phafes of the eclipfe perfectly. But it is evident that the reticule, whether fquare or circular, ought to be perfectly equal to the diameter or circumference of the fun or ftar, fuch as it appears in the focus of the glafs; otherwife the divifion cannot be juft. Now this is no eafy matter to effect, becaufe the apparent diameter of the fun and moon differs in each eclipfe; nay, that of the moon differs from itfelf in the progrefs of the fame eclipfe. Another imperfection in the reticule is, that its magnitude is determined by that of the image in the focus; and of confequence it will only fit one certain magnitude. See MICROMETER, *Encycl.*

REVETEMENT, in fortification, a ftrong wall built on the outfide of the rampart and parapet, to fupport the earth, and prevent its rolling into the ditch.

REVIVIFICATION, in phyfiology, the recalling to

(A) For this view of the *Refidual Analyfis*, we are obliged to Mr Playfair profeffor of Mathematics in the Univerfity of Edinburgh.

to life of animals apparently dead. There are many kinds of inſects which may be revivified, after all the powers of animation have been ſuſpended for a conſiderable time. Common flies, ſmall beetles, ſpiders, moths, bugs, &c. after being drowned in ſpirit of wine, and continuing apparently dead for more than a quarter of an hour, have been reſtored to life merely by being thrown among wood aſhes ſlightly warm.

While Dr Franklin reſided in France, he received from America a quantity of Madeira wine which had been bottled in Virginia. In ſome of the bottles he found a few dead flies, which he expoſed to the warm ſun, it being then the month of July; and in leſs than three hours theſe apparently dead animals recovered life which had been ſo long ſuſpended. At firſt they appeared as if convulſed; they then raiſed themſelves on their legs, waſhed their eyes with their fore feet, dreſſed their wings with thoſe behind, and began in a little time to fly about.

But the moſt extraordinary inſtance of revivification that we ever heard of, is the following: In the warmer parts of France there is an inſect very deſtructive to rye, which ſeems to begin its operations at the root of the plant, and gradually to proceed upwards to the ear. If the plant be completely dried while the inſect is in the root or ſtem, the animal is irrecoverably killed; but after it has reached the grain, the caſe is very different. There have been inſtances, which are noticed in the Academy of Sciences, of theſe inſects being brought to life in a quarter of an hour, by a little warm water, after the grains, in which they were lodged, had been kept dry for 30 years.

What is the metaphyſician to think of theſe phænomena, or what concluſion is he to draw from them with reſpect to the mind or ſentient principle? If he be a ſober man, he will draw no concluſion; and for this very good reaſon, that of the ſentient principle of inſects, and indeed of every animal but man, he knows nothing. He is conſcious that it is the ſame individual being, which, in himſelf, thinks, and wills, and feels; he knows, that part of his thought is not in one place and part of it in another; and therefore he rationally concludes that this thinking being is not matter, whilſt experience teaches him that it quits the material ſyſtem as ſoon as that ſyſtem becomes completely unfit to diſcharge its functions, and that when it has once taken its flight, it cannot be recalled. Experience teaches him, on the other hand, that the ſentient principle of theſe inſects does not quit the material ſyſtem as ſoon as that ſyſtem ſeems unfit for its functions; and hence he ought to infer, that the minds of men and of inſects (if we may uſe ſuch language), though probably both immaterial are very different ſubſtances; and that the bond which unites the material and immaterial parts of an inſect, is certainly different from that which unites the mind and body of man. This is the only inference which can be legitimately drawn from theſe phenomona; and he who makes them the baſis of materialiſm, muſt have his judgment warped by ſome paſſion or prejudice.

216 Narrative continued. REVOLUTION of France. We formerly preſented to our readers a conciſe ſtatement of the commencement and progreſs of this extraordinary event (See Revolution, *Encycl.*). The ſingularity of its nature, and the important place which it muſt hereafter occupy in the moral and political hiſtory of mankind, require that we ſhould now reſume and continue the detail of its wide waſting career. We left the ſubject towards the commencement of the year 1795, at the cloſe of that wonderful campaign, during which the armies of the Republic had exerted themſelves with ſuch unparalleled ſucceſs in every direction. On the one ſide they had croſſed the Pyrenees, and ſhaken the Spaniſh monarchy to its centre; while on the other they had driven the united forces of Auſtria, Pruſſia, and Britain, from the walls of Landrecies acroſs the Rhine, at all points from Hageneau to the ſea, and had finally cloſed their efforts by the conqueſt of Holland. At that period, though a prolongation of hoſtilities was threatened, we ſcarcely expected that Europe was ſo ſoon to witneſs, or we to record, a ſucceſſion of military enterpriſes of a ſtill more romantic and extraordinary nature, the ſcene of which was even to extend into barbarous countries, where the opinions and the quarrels of the European nations had hitherto remained unknown.

217 Diminiſhed energy of the Convention, The campaign of 1794, however, was not immediately followed by any important military exertions. The Britiſh troops were recalled home, Pruſſia had been gradually withdrawing from the coalition, and the Auſtrian armies remained upon the defenſive. Neither was the French government in a ſituation which could enable it to renew its enterpriſes with vigour, or to give much trouble to the allies. The Convention ſtill exiſted; but it was no longer that terrible aſſembly which, under Robeſpierre and his aſſociates, had, in the ſhort period of fifteen months, reduced two thirds of France under its dominion, and ſent forth armies which the combined ſtrength of the reſt of Europe ſeemed unable to reſiſt. While its authority remained almoſt concentrated in one man, and while the fear of foreign invaſion, and the new born enthuſiaſm for freedom, induced the people to ſubmit to every meaſure of government, however oppreſſive or arbitrary, the power of the Convention, and the number of its armies, were unbounded. The dreadful price, however, which they had paid for liberty, and the facility with which they ſaw it might be loſt, had now diminiſhed the political zeal of all claſſes of citizens. The removal of the foreign armies had diſpelled the dread of invaſion, and the death of Robeſpierre, by diſſolving the unity of its efforts, and ſuffering it to fall into contending factions, had greatly weakened the authority of the Convention, and diminiſhed its efficiency as a government.

The fall of Robeſpierre had been accompliſhed by two ſeparate conſpiracies. At the head of one of theſe were, Barrere, Billaud Varennes, and Collot d'Herbois, who had been members of the Committee of public ſafety. The other conſpiracy conſiſted of members of the Convention who did not belong to the committees, and had no immediate ſhare in the adminiſtration. Among theſe, Tallien, Bourdon de l'Oiſe, and Lecointre of Verſailles, were conſpicuous. After the deſtruction of their mutual tyrant, a conteſt for power took place between theſe parties. The popularity of Robeſpierre had once been ſo conſiderable, and all men had ſubmitted ſo tamely to his dominion, that both parties accounted it neceſſary, in their ſpeeches and writings, to juſtify to the nation the ſhare they had taken in accompliſhing his ruin. It was eaſy to be eloquent upon ſuch a topic; but its diſcuſſion naturally operated to the diſcredit of the members of the committee, and of the 219 And diſcredit of the Jacobins, the more violent Jacobins, who had been the immediate instruments for carrying into effect his sanguinary measures. They nevertheless retained possession, for some time, of a considerable portion of power. The current of public opinion, however, ran so strongly against them, and the restoration to their seats in the Convention of the seventy one imprisoned members of the Girondist party, added so much to the strength of their antagonists, that they gradually lost their influence, and were threatened to be brought to trial for their conduct.

As early as August 1794, Lecointre of Versailles had denounced the members of the old committee of safety; but his accusation at that time produced little effect. Towards the end of that year, however, their approaching fall became evident. On the 26th of December the Convention ordered, on the motion of Clauzel, that the committees should immediately report upon the conduct of the representatives denounced by Lecointre and all France. Accordingly, on the following day, Merlin of Douay reported, in the name of the committees, that there was no cause for inquiry into the conduct of Vouland, Amar, and David; but that there was room for examining the conduct of Barrere, Billaud Varennes, Collot d'Herbois, and Vadier.

219
Whose leaders were accused,

In consequence of this report, a committee of twenty-one members was appointed to make the enquiry. On the 2d of March this year (1795), Saladin presented the report of the commission; in which these four deputies were accused of having participated, as members of the governing committee, in the tyranny and atrocious measures of Robespierre. Their trial commenced before the Convention on the 22d of March; but previous to that period, Vadier had made his escape. The others remained, and rested their defence upon this ground, that although members of the committee of safety, they had no power to resist Robespierre, and that they were not more culpable in having acquiesced in his tyranny than the other members of the Convention, who had all been overpowered for the time by the knowledge that instant destruction awaited every man who should dare to oppose his measures. Except in the case of the cruelties committed by Collot d'Herbois at Lyons, this defence was probably by no means destitute of foundation. It had much weight with the nation at large; in whose eyes it tended, not to exculpate the three persons now accused, but to criminate and degrade the character of the whole Convention.

220
and defended by their faction;

Carnot, Lindet, Cambon, Duhem, and the other members of what was now called the *Jacobin party*, defended their leaders with considerable ability, and with much vehemence. Nor was the party less active without doors than within the hall of the Convention. For some time they had drawn their friends to the capital from all quarters of the country; and in the morning sitting of the first of April, they commenced their operations by an open insurrection. An immense multitude having assembled in the suburbs, proceeded to the hall of the Convention. A real or factitious scarcity existed at the time. Taking advantage of this circumstance, they pretended they were going to petition for bread; and this pretence drew numbers along with them who had no share in their designs.

Boissy d'Anglas, a conspicuous member of the moderate party, was addressing the Convention upon the means of removing the present scarcity when the insurgents arrived, drove the centinels from their posts, and suddenly filled the hall. They tumultuously demanded "Bread, and the Constitution." The Jacobin party supported the insurgents; and one of the multitude, in a vehement harangue, exclaimed, "We are men of the 14th of July, of the 10th of August, and of the 31st of May." He demanded, that the Convention should change its late measures, that the people should no longer be the victims of mercantile rapacity, and that the accused patriots should not be sacrificed to the passions of their antagonists. The Convention ordered the tocsin to be rung, and the people of Paris to be called to arms. General Pichegru was in Paris at the time; and, upon the motion of Barras, he was appointed to the command of the military force.

221
Which is quelled by Pichegru.

The citizens of Paris, who remembered with horror the domination of Robespierre and his adherents, and now saw themselves menaced with its return, instantly called each other to arms, and assembled, by six in the evening, for the protection of the Convention, to the amount of 20,000 men. Till that time the assembly had remained under no small disquietude, surrounded by the insurgents, and listening to the addresses of their orators, and the speeches of the Jacobin minority in their favour. The majority was now rescued from this state of constraint; and, on the motion of Dumont, without proceeding farther in the trial, it was decreed that Barrere, Collot d'Herbois, and Billaud Varennes, should immediately be transported to Guiana.

222
Victory of the Convention.

During the following day the insurgents were completely subdued; and the majority of the Convention, taking advantage of their victory, decreed the arrest and confinement, in the castle of Ham in Picardy, of several of the most obnoxious of their antagonists. Among these were Leonard Bourdon, Duhem, Chasles, Choudieu, Ruamps, Foussedoire, Huguet, Bayle, Lecointre, Cambon, Thuriot Maignet, Heutz, Crassous, and Levasseur. By departing from the punishment of death, and adopting that of banishment on this occasion, the Convention expected to diminish the ferocity of the contending factions in the state, by rendering the result of a political defeat less fatal than formerly. The design was good; but in attempting to accomplish it, they established the pernicious precedent of inflicting punishment without a trial, which could scarcely fail to prove highly dangerous, if not ultimately fatal, to all their prospects of a free and just government.

223
Proposal for a new constitution.

The Convention now followed up its victory with the popular measure of preparing for its own dissolution, by endeavouring to frame a fixed constitution for the Republic. The constitution which had been decreed in 1793, under the auspices of Robespierre, was considered as impracticable, and a committee was appointed to report upon the measures which ought now to be adopted. It consisted of Sieyes, Cambaceres, Merlin of Douay, Thibaudeau, Mathieu, Le Sage of Eure and Loire, and Latouche. On the 19th of April, Cambaceres reported, that it was the opinion of this committee that a commission should be appointed to frame an entirely new constitution. The Convention accordingly appointed the following persons to this important office, Le Sage, Louvet, Boissy d'Anglas, Creuze, Latouche, Bertier, Daunow, Baudin, Durand, Maillane, Languinais, La Reveillere Lepaux, and Thibaudeau. All other citizens of every description were at at the same time invited to communicate projects upon the subject, and the committee was required to order the best conceived of these to be printed.

The Convention farther gratified the feelings of the great majority of the nation, by bringing to trial Fouquier Jenville the president, and fifteen judges and jurors of the late revolutionary tribunal. They were convicted on the 8th of May, and executed on the following day, amidst the execrations of a multitude of spectators.

224
New insurrection of the Jacobins,

In the mean time, though defeated on the 1st and 2d of April, the Jacobins by no means considered themselves as subdued. On the contrary, they were preparing a new and more extensive insurrection, which should not, like the former, be confined to the capital. They fixed upon the 20th of May as the day of revolt. Thuriot, and Robespierre's financier Cambon, had found means to escape from the castle of Ham in Picardy, and to come to Paris. They concealed themselves in the suburb St Antoine, and from thence gave counsel to their party, and urged them to action. The scarcity of bread had increased, and advantage was again taken of this circumstance. For some days the walls were covered in various places of Paris with printed accusations against the Convention of withholding bread from the people, and attempts were made to excite the troops in the city to join the disaffected party. On the evening of the 19th, a paper was openly distributed in the different sections, explaining the object of the approaching insurrection. It declared insurrection to be the most sacred duty of the people, and called upon the citizens of Paris to proceed in a mass to the Convention, to demand from it bread and the establishment of Robespierre's constitution, together with a new election of national representatives.

On the morning of the 20th, the tocsin was rung, and drums beat to arms in the suburb St Antoine, which had always been the quarter of the city in which the Jacobins possessed the greatest strength. Upon this alarm the Convention assembled; but although the intended insurrection was no secret, and though the committee of public and general safety now made a report, in which they confessed their previous knowledge of it, yet it does not appear that any vigorous measures of precaution had been taken; for it was only at the instant when the insurgents were actually approaching that General Hoche was appointed to command the armed force, and was sent forth to assemble the military and the citizens for the defence of the Convention. In the mean time, the multitude surrounded the hall. They soon overpowered the guards, and burst into the midst of the assembly. In all the turbulent days of the revolution, the women of Paris have never failed to act a conspicuous part. On this occasion they greatly augmented the crowd by their numbers, and the tumult by their cries of "Bread, and the constitution of 1793," which was the rallying exclamation of the party. After some fruitless efforts to restore tranquillity, Vernier the president, an old man, resigned the chair to Boissy d'Anglas, who remained in it with much firmness during the day. The whole strength of the insurgents had not arrived at once; for the first party that approached, although they forced their way into the hall, were soon repulsed by the aid of a few soldiers and citizens, who came to the assistance of the Convention. A short interval of tranquillity was thus obtained; but the attack was speedily renewed with double fury by armed men, who subdued all opposition, and entered the hall with cockades, on which was written the inscription, "Bread, and the constitution of 1793." While things were in this state, a citizen of the party of the Convention rashly tore off the hat of one of the insurgents, and was immediately assaulted with swords by the multitude. He fled towards the president's chair, and was killed at the side of it by a musket shot. Ferand, one of the members, having attempted to rescue him, was also attacked. He escaped into one of the passages, where he was also killed, and his head was brought into the Convention upon a pike. The greater number of the members now gradually departed, and left the hall in possession of the insurgents, who acted with some regularity, and proposed a variety of laws favourable to their party, which were instantly decreed. Duroi, Duquesnoi, Bourbotte, and Goujon, were the members who stood most openly forward on this occasion, and appeared as chiefs of the insurrection. But their triumph only lasted a few hours. Towards the evening a large body of citizens joined the military, and marched to the aid of the Convention. Having overcome the insurgents, they entered the hall in great force, and restored the powers of the majority. The decrees that had been forced upon them were repealed as speedily as they had been enacted, and the deputies who had proposed or supported them were arrested.

225
Who murder some of the Convention, and drive it from its hall.

The citizens of Paris, and even the members of the Convention, appear now to have fancied their victory complete; for they adopted no adequate measures to prevent a new disturbance. But the Jacobins did not so easily give up their own cause. On the following day they once more assembled in the suburbs, and in the afternoon they returned to the attack. They took possession of the Carousal without opposition, and pointed some pieces of cannon against the hall of the Convention. This assembly was now unprotected, and attempted not to subdue, but to flatter, the insurgents. A deputation of the members was sent forth to fraternise with them, and to carry forth two decrees passed at that instant, which ordained that bread should abound, and that Robespierre's constitution of 1793 should immediately be put in force. The insurgents, in return, sent a deputation to the Convention, to express their satisfaction with the decrees, to demand the release of the imprisoned patriots, and the punishment of those who preferred money to assignats. The Convention pretended to agree to all their demands, and the president was ordered to give to the deputation the fraternal embrace.

226
Meanness of the Convention.

The 22d, which was the third day of the insurrection, appears to have been passed by both parties in a strange degree of inaction. The Convention proceeded in its ordinary business; and the Jacobins, at their head quarters in the suburb St Antoine, were occupied in consultations and preparations for new movements. But on the following day the citizens assembled at their sections, and hastened from thence to the Thuilleries to defend the Convention. Considerable bodies of the military were also collected, and the assembly at last resolved to act upon the offensive. A decree was passed, declaring, that if the suburb St Antoine did not instantly surrender its arms and cannon, together with the

the murderer of Ferand, it ſhould be conſidered as in a ſtate of rebellion. The conventional generals were at the ſame time ordered to reduce it by force. The in-
227 ſurgents now found themſelves unequal to the conteſt, and were compelled to ſurrender without conditions by the inhabitants of the ſuburb, who dreaded the deſtruction of their property by military operations. Several ſoldiers being found among the priſoners, were put to death; and ſix members of the Convention were tried and condemned on this occaſion by a military commiſſion. Three of theſe periſhed by ſelf-ſlaughter, and three were executed. The majority of the Convention, elated by their victory, ordered back Collot D'Herbois, Billaud Varennes, and Barrere, to take their trial; but the two former had ſailed before the arrival of the courier. Barrere only remained, and he was brought back and impriſoned.

Its victory over the Jacobins;

In the mean time, the Jacobins in the ſouth were not leſs active than their brethren at Paris. On the 20th of May they formed a vigorous inſurrection at Toulon. They ſeized the gates and mounted them with cannon; they liberated ſuch of their aſſociates as had been impriſoned, and detained the fleet which was about to ſail. Having begun their operations in this ſucceſsful manner, they marched from Toulon towards Marſeilles. Their force amounted to three thouſand men and twelve pieces of cannon. They were encountered on their way, however, and defeated by Generals Charton and Pactod. Three hundred of them were carried priſoners to Marſeilles, and Toulon was ſpeedily retaken.

The party of the *Mountain*, as it had been called, or of the violent Jacobins, who wiſhed to revive the reign of terror and the meaſures of Robeſpierre, was now reduced very low both in the Convention and out of it. Thoſe who adhered to it were even in many places, and more eſpecially in the ſouth, expoſed to very violent perſecution. Aſſociations were formed, called Companies of *Jeſus* and of the *Sun*, for the purpoſe of avenging the crimes committed by them during the period of their power. At Lyons ſeveral of them were maſſacred in priſon, and many of them in all places periſhed by aſſaſſination. On conſidering the mercileſs character of the government of Robeſpierre and his aſſociates, and the perſecution which was ſuffered under it, not merely by the nobles and the rich, but by every man who was diſtinguiſhed by integrity, talents, or literature, it may appear ſurpriſing that it ſhould have obtained admirers, or that any number of individuals ſhould have been found willing to hazard their lives to procure its reſtoration. Accordingly, from the period of the fall of its leader, the party had gradually been forſaken by its adherents; and the more cloſely its conduct was conſidered, it loſt ground the more rapidly in the eſtimation of the public. After the unſucceſsful inſurrections of the 20th of May, it was treated with the utmoſt contempt, and its unpopularity was extreme. Still, however, a party remained. It was ſmall,
228 indeed, but its members compenſated the inferiority of their numbers by ſuperior enterpriſe and activity. They conſiſted of outrageous republicans, whoſe heated imaginations beheld royalty and ariſtocracy in every propoſal for ſober and regular government. In the conduct of Robeſpierre, they remembered only the energy of his meaſures, by which France was enabled to triumph over the combined efforts of the kings of Europe; and overlooked the atrocities by which he had brought diſgrace upon their cauſe, and rendered his party odious to their own countrymen, as well as to the neighbouring nations. Amidſt the univerſal odium, however, the Jacobins did not deſpair of riſing once more into power; and it is not a little ſingular, that we muſt date the revival of their ſtrength from the period of the unſucceſsful inſurrections which we have juſt recorded, and which ſeemed to have extinguiſhed their hopes for ever.

[W]ho ſtill [re]tain their [ſp]irit;

The unpopularity under which the Jacobins laboured ſoon began to affect the Convention itſelf. The tame ſubmiſſion of that body to the government of Robeſpierre was now remembered. It was recollected, that the majority of its members had been the inſtruments of his power, and had applauded, or at leaſt acquieſced in, his crimes. As the preſs was now free, and the reins of government unſteadily held, their conduct was repreſented to the public in the moſt odious colours. A celebrated ſong, *Le Reveil du Puple*, became extremely popular, as the means of marking diſlike both to the Convention and to the Jacobins; and their conduct was canvaſſed with the utmoſt bitterneſs in a great variety of publications, but more eſpecially in a journal that at this time attracted much notice, and which was conducted by Freron, who had himſelf been a Jacobin, but had now abondoned his party.

In this ſtate of things, the majority of the Convention ſpeedily began to repent of their late victory over the Jacobins. In the firſt efforts of their zeal, they had taken meaſures for the immediate formation and eſtabliſhment of a ſettled conſtitution to ſuperſede their own authority; but they now regretted their raſhneſs, when they perceived, from the temper the nation was in, that the men, the moſt avowedly hoſtile to their character and meaſures, would without doubt be elected as their ſucceſſors. They, and their friends, had ariſen to great diſtinction and wealth under the revolutionary government; and they now began to dread, not only the loſs of power, but alſo a ſevere inveſtigation of their conduct. Theſe conſiderations ſoon produced their natural effects. The decrees for forming and putting in force the conſtitution could not decently be recalled; but the majority of the Convention ſet about deviſing means for rendering them of little importance, ſo far as they themſelves were concerned. 229

And terrify the Convention.

On the 23d of June, Boiſſy D'Anglas preſented the report of the committee that had been appointed to prepare the plan of a conſtitution. It began, like the former conſtitutions, with a declaration of the rights of man; and in addition to this, conſiſted of fourteen chapters, upon the following ſubjects:—The extent of the territorial poſſeſſions of the Republic, the political ſtate of citizens, the primary aſſemblies, the electoral aſſemblies, the legiſlature, the executive power, the municipal bodies, the judicial authority, the public force, public inſtruction, the finances, foreign treaties, the mode of reviſing the conſtitution, and, laſtly, an enactment, that no rank or ſuperiority ſhould exiſt among citizens, excepting what might ariſe from the exerciſe of public functions. 230

New conſtitution, conſiſting of

The primary aſſemblies were to poſſeſs the right of electing the members of the electoral aſſemblies, and alſo the juſtices of the peace. The electoral aſſemblies were to nominate the judges and the legiſlators of the ſtate,

French Revolution, 1795.

ftate. The legiflature was divided into two affemblies; the one of which confifted of 250 members, and was called the *Council of the Ancients*, as none but married men and widowers above 40 years of age could be members of it. The other affembly or council confifted of 500 members, and poffeffed the exclufive privilege of propofing the laws; the Council of Ancients being only intitled to reject or approve, without power to alter the decrees prefented to it. To this rule there was one exception, which was afterwards employed as the means of overturning the whole fabric of the conftitution; the Council of the Ancients might decree the removal of the legiflature from its ordinary place of fitting. To this decree the approbation of the Council of Five Hundred was not neceffary; and when once enacted, it could not be confidered even by the Council of Ancients itfelf. One-third of the members of the two Councils was to be elected annually. A member might he once re-elected but he could not be elected a third time till an interval of two years had elapfed.

231 Two Councils and an

232 Executive Directory.

The executive power was intrufted to five perfons of forty years of age at leaft, to be ftyled the *Executive Directory*. Its members were elected by the two Councils; the Council of Five Hundred electing ten times the number of candidates that might be neceffary to fill up the vacancies, and the Council of Two Hundred and Fifty nominating the directors from this lift of candidates. One member of the Directory was to go out annually; fo that the whole might be changed every five years. The Executive Directory had no vote in the enactment of laws; but it fuperintended their execution, regulated the coining of money, and difpofed of the armed force. Foreign treaties made by it were not binding till ratified by the legiflative body, nor could it make war without the authority of a decree of the two affemblies. The public functionaries were to receive falaries, and to appear dreffed in an appropriated habit.

Each article of this conftitution was feparately difcuffed; and on the 23d of Auguft the whole was declared to be complete, and ordained to be tranfmitted to the primary affemblies for their approbation. Previous to this refolution, however (that is, on the 22d of the fame month), the majority of the Convention had brought forward the grand meafure by which they meant to provide for their own fafety, and the fafety of their friends and adherents, againft the change which the public opinion had undergone concerning them. They decreed, that at the approaching general election, the electoral bodies fhould be bound to choofe *two-thirds* of the new legiflature from among the members of the prefent convention; and they afterwards decreed, that, in default of the election of two-thirds of the Conventioo, the Convention fhould fill up the vacancies themfelves.

233 The convention fetters the freedom of election.

Thefe decrees were tranfmitted, along with the Conftitution, to the primary affemblies, to be accepted or rejected by them. Many of the primary affemblies underftood, that they could not accept of the conftitution without accepting along with it the law for the re-election of the *two-thirds*. The point had, in all probability, been purpofely left under a certain degree of ambiguity; and as the people were now weary of this Convention, they acquiefced in any conditions that gave them the profpect of one day getting quit of it. But at Paris, and in the neighbouring departments, where the fubject was more accurately inveftigated, the public difapprobation of the Convention difplayed itfelf with great vehemence.

234 Confequences of this conduct.

There was indeed fomething extremely aukward in the decree about the re-election of two-thirds of the Convention. That body might, if neceffary, have continued its own exiftence for fome time longer, or it might have difmiffed one third of its number by ballot or otherwife, and allowed a new election only to that extent; but a compulfory election was an abfurdity fo new, and fo obvious, that it gave their antagonifts every advantage againft them. Accordingly, at the meetings of the fections of Paris, the laws for the re-election were rejected with contempt, and their abfurdity demonftrated with much acrimony. In confequence of the debates which took place at thefe meetings, the minds of men were gradually inflamed, and it became obvious that a political convulfion approached. On the one fide, the Convention took care to publifh daily the approbation of the decrees, along with the conftitution, by the majority of the primary affemblies, by moft of which the two had been confounded and accepted in the grofs. Its committees alfo called in the aid of the troops of the line for its protection. On the other hand, the language of the fections became every day more violent. The whole Convention was reprefented as a band of tyrants and of murderers, the affociates of all the cruelty of Robefpierre and the Mountain party. It was even propfed to bring to trial every individual member of the affembly before a new revolutionary tribunal, and to punifh him according to his demerits.

For fome time much anxiety prevailed on both fides. Numerous deputations were repeatedly fent from the fections to the Convention to remonftrate againft the obnoxious decrees. But the eagernefs with which thefe remonftrances were made, ferved only to convince more ftrongly the members of the Convention of the danger to themfelves as individuals which would attend a refignation of their power, and confirmed the refolution they had taken to retain it. The deputies of the fections having obtained infpection of the records of the convention, afferted, that the national majority, if rightly numbered, had rejected the decrees, as every affembly that voted in oppofition to them was only numbered as one vote, however numerous its members might be; which enabled the primary affemblies of remote diftricts to outvote the more populous fections of Paris and other great towns. Whereas it was faid, that if the individual voters were counted, it would be found that the decrees were difapproved of by a confiderable majority. All this was difregarded by the Convention, and the fections prepared to decide the difpute by arms. The firft ftep taken by them, however, was ill concerted. A notion was propagated, that as foon as the primary affemblies or fections had chofen the electors who were to choofe the members of the new legiflature, the national fovereignty became vefted in thefe electors, and that they had a right to affume the government in their various diftricts. Accordingly, about 100 of the electors of Paris affembled in the hall of the French theatre in the fuburb St Germain, previous to the day of meeting appointed by the Convention. Having chofen

De

French Revolution, 1795.

De Nivernois (formerly the Duke de Nivernois) their prefident, they began their debates. The Convention was alarmed, and inftantly fent a body of the military to difmifs the meeting as illegal. This was eafily accomplifhed, as the citizens had not been unanimous with regard to it, and no meafures were taken for its protection.

Notwithftanding this firft advantage on the fide of the Convention, the fections regarded its power with contempt, and imagined themfelves fecure of ultimate fuccefs. In every political conteft that had hitherto occurred fince the commencement of the revolution, the immenfe population of the capital had given a decifive fuperiority to the faction whofe fide it efpoufed. The citizens alfo regarded with indifference the armed force with which the Convention had furrounded itfelf, from a notion, which they fondly entertained, that the military would in no cafe be brought to act againft the people. It would appear that the Convention itfelf entertained fome jealoufy upon this head, and did not account itfelf entirely fafe under the protection of the foldiers. On this occafion, therefore, it had recourfe to a new ally, and befought the aid of thofe very Jacobins whom it had almoft crufhed on the 24th of May. The members of the Convention were odious to the fections of Paris, on account of their participation in the revolutionary crimes and meafures of Robefpierre; but this very circumftance endeared them to the Jacobins, whofe character it was to imagine that they had never enough of war abroad or of revolution at home. It was eafy therefore to bring about a reconciliation between the Convention and thefe men. Several hundreds of them were difmiffed from the prifons, where they had been confined fince the two laft infurrections, and they were now put in requifition to defend the legiflative body.

235 The Convention courts the Jacobins.

When the fections of Paris beheld the Convention furrounded by thofe Jacobins who had been the unrelenting agents of the government of Robefpierre, and who were now denominated *terrorifts* and *men of blood*, their ardour for action became unbounded. They affembled in arms at their different fections on the 12th Vendemaire (October 4th); but they do not feem to have acted with much concert, or upon any well digefted plan of operations. The general defign of their leaders was to feize the members of the Convention, and imprifon them in the church of the Quatre Nations till they could be brought to trial. As this would occafion a vacancy or interregnum in the government, it was refolved that all affairs fhould be conducted by committees of the fections, till a new legiflature could be elected. General Miranda, a Spaniard, a native of the Carraccas in South America, who had ferved in the republican armies, was to be appointed to the chief command of the armed force after the overthrow of the Convention. This man, in his eagernefs for preferment, had alternately courted all parties, and he now feems to have joined the Parifians upon the fuppofition of their being the ftrongeft. As he entertained fome doubts of their fuccefs, however, he adopted the crooked and timid policy of avoiding the ftorm by retiring from the city till the combat fhould be finifhed, refolving to return immediately on its conclufion to fhare the rewards and the triumph of victory.

The Convention, in the mean time, refolved to ftrike the firft blow. For this purpofe they fent General Menou to the fection of Le Pelletier to difperfe the citizens, whofe greateft force was affembled there. But this officer difliking the fervice which he was employed to perform, inftead of proceeding to action, began to negociate with the leaders of the fections, and fpent the evening of this day in fruitlefs conferences. The fections on their fide appointed General Danican, who had diftinguifhed himfelf in the war againft the Royalifts in La Vendee, to act as their military leader. It would appear, however, that this officer, from the moment that he affumed the command, began to defpair of the caufe of the fections. He found them totally deftitute of cannon, whereas the Convention was furrounded by regular troops and a numerous artillery. This inequality in point of weapons appears to have been confidered by him as a fufficient reafon for avoiding an engagement. Occupied in vifiting and arranging the different pofts, he was unacquainted with the difaffection of the conventional generals. He therefore thought he had done much when he had prevented bloodfhed for another day, and thus the favourable moment for attack was loft. Whether the fections would have been fuccefsful had they been inftantly led to battle on this important occafion, cannot now be known. Though the fuperior officers of the Convention were unfaithful, yet the fubalterns and the troops in general might have ftood firm, confirmed as they were by the perfuafion of their Jacobin auxiliaries. Even in this cafe, however, the fate of a battle might have at leaft been doubtful. The battalions of Paris were very numerous, their contempt of danger was great, and their ardour unbounded. The mere poffeffion of cannon might not in a conteft againft fuch men have afforded fecurity to the Convention. But the firft moments of popular enthufiafm were fuffered to pafs away, and that diftruft and diffenfion, which delay never fails to introduce among great and irregular affemblages of men, foon began to render the conduct of the fections undecided and weak.

The conventional committees, during the night of the 12th Vendemaire (October 4th), difmiffed Generals Menou, Raffet, and fome others, from their ftations, and gave the command of the troops to Barras. He immediately collected around him a variety of able officers, among whom we find the names of Generals Brune and Bonaparte. With their affiftance he began to provide for a moft vigorous defence. Troops with cannon were ftationed in all the avenues leading to the Thuilleries. In cafe any of thefe pofts fhould be forced, mafked batteries were planted in more retired fituations. Nor was this all; meafures were taken for conveying the public magazines of provifions and military ftores to St Cloud, whither the Convention prepared to retreat if they fhould fuffer a defeat at Paris.

On the 13th Vendemaire (October 5th), from which the infurrection was afterwards named, both parties remained for many hours upon the defenfive. At laft, about three o'clock in the afternoon, General Danican made advances to an accommodation by a letter to the committee of public fafety; in which he ftated, that the only caufe on account of which the citizens had taken arms was the dread of a maffacre being intended by the armed terrorifts who furrounded the Convention, and that if thefe men were removed, tranquillity would immediately be re-eftablifhed. A civil meffage was returned;

French Revolution, 1795. turned; but the Jacobin party in the Convention, being now more confident of victory, and wishing to strengthen themselves, by the defeat and punishment of their antagonists, it was resolved that the dispute should be decided by arms. It is not correctly known how the contest commenced, but the armed Jacobins are most generally understood to have begun the attack. The citizens on the southern side of the river attempted to reach the Convention by the Quay de Voltaire, but were speedily repulsed by the conventional cannon; but on the northern side of the river, near the Convention, the combat was extremely obstinate. The cannon were repeatedly seized by the citizens, and repeatedly retaken by the troops and the armed Jacobins. It was not till after a contest of four hours that the sections were repulsed and driven to the post of St Roch. This post was also taken after great slaughter, and the sections were driven to their head quarters at the section of Le Pelletier. After a short interval they were pursued thither by the troops of the Convention, who by midnight were masters of the whole city.

236 Subdues the citizens of Paris.

This insurrection was ascribed by the victorious party to the exertions of the Royalists. It is no doubt true, that by this time Royalty was become less unpopular even among the rabble of France than the extreme of Republicanism, as it had appeared in the conduct of the Mountain party. It is also probable, that the Royalists mingled in a contest that had the overthrow of the present Convention for its object; but the insurgents in general seem neither to have avowed nor entertained any farther view than the disarming of the Jacobins, and the obtaining an immediate election of new representatives. The failure of the attempt had the effect of placing the Mountain party once more at the head of the state. This party at first thought of adjourning the new constitution, and of renewing all the terrors of the revolutionary government. This project, however, was opposed in the Convention with so much vehemence and ability by Thibaudeau, that it was renounced. Indeed it was become unnecessary to the safety or ascendency of the men who proposed it, as the decrees for the re-election of two-thirds of the Convention enabled them to retain the full possession of their power. A few members of the moderate party, such as Boissy D'Anglas, Languinais, and Le Sage, were elected by almost every place in France, though they could only sit for one place. Hence the Convention itself had the re-election of nearly two-thirds of its own members; and the Mountain party, which now commanded the majority, was thus enabled to fill the new legislature with its own leaders.

237 Mountain party, or the most violent Jacobins, again at the head of the state.

On the 27th of October the Convention terminated its sittings, and was succeeded by the new legislature as appointed by the Constitution. By its last decrees, a general amnesty was granted for all revolutionary crimes and proceedings. From this amnesty, however, were excepted the emigrants, the transported priests, and all persons concerned in the last insurrection; so that in fact it was merely a pardon granted by the Mountain party to its own friends for all the excesses they had committed. The members of the Convention, who had been imprisoned in the castle of Ham since the Jacobin insurrection in May, were now set at liberty. The members of the revolutionary committees, and other agents of Robespierre in Paris and the departments, were all dismissed from their prisons, and advanced to the most important offices under the new government.

238 First sitting of the new legislature.

As soon as the new legislature had divided itself into two councils, it proceeded to the election of an Executive Directory. Here the genius of the French nation for intrigue instantly displayed itself. The Council of Five Hundred was bound to present to the Council of Two Hundred and Fifty a list of ten times the number of candidates necessary for the office. It fulfilled this duty in the following manner. The majority of the Council of Five Hundred made out a list, consisting of the five following persons, upon whom they wished the election ultimately to fall: Sieyes, Barras, Rewbell, La Revellere Lepaux, and Letourneur de la Manche. To complete the list, they added the names of 45 obscure persons, country justices, farmers, and even peasants. Thus there was nothing left to the Council of Ancients but the mere form of an election; and from the want of other qualified candidates, they were under the necessity of nominating to the office of directors the five persons at the head of the list presented by the Council of Five Hundred. The crafty Sieyes, however, who had been the adviser of all parties, but the ostensible agent of none, did not yet think fit to venture upon the possession of power. He had disapproved of the constitution which was now put in force, and had even framed one of his own in opposition to it, which, however, was rejected by the Convention. The most remarkable circumstance in his plan of government was a national jury, upon which he proposed to confer the power of dismissing from their offices, without a cause being assigned, any of the public functionaries whom they might account dangerous to the state. Sieyes having refused to accept the office of director, Carnot was elected in his stead. But on this occasion the Council of Ancients was treated with a little, and but a little, more decency than formerly; as the name of Cambaceres, a man of considerable eminence, appeared along with that of Carnot in the list of candidates voted by the Council of Five Hundred.

239 The Council of Five Hundred outwits the Council of Ancients.

The republican government that was now attempted to be established promised little tranquillity to the nation. This great misfortune attended it, that the chief offices in the state were intrusted to men who were disliked by the people. The members of the Executive Directory, with the exception of Reveillere Lepaux, had always belonged to the Mountain or most violent Jacobin party. As they now owed their power to that party, they employed its members in almost every official department. The government was therefore necessarily unpopular. Things might have been gradually altered, indeed, by successive elections, which would in time bring other men into power: But by the forms of the constitution, the executive power was more permanent than the legislative body, without possessing any influence over it. Hence it was to be feared that a contest for power might speedily occur between a directory nominated by the Jacobin party and the new legislators appointed by the people, in which the Constitution might suffer shipwreck; an event which actually occurred.

240 New government not popular.

While the possession of power continued to fluctuate in the manner we have already stated, between the Moderate and the Jacobin or Mountain parties, the armies of the state were suffered to languish; but upon the credit

French Revolution, 1795.

credit of its former military succefs, the Republic was treated with refpect by fome of the neighbouring powers. On the 10th of April, a treaty of peace with Pruffia, which had been negociated by the committees through the medium of Barthelemi the French refident at Bafle, was prefented to the Convention for ratification. By this treaty, it was ftipulated, that the French troops fhould immediately evacuate the Pruffian territory on the right bank of the Rhine, but fhould retain the territory belonging to that power on the left bank till a general peace. Prifoners of war were to be mutually reftored, and the commerce of the two countries was to be placed on its ancient footing. Meafures were alfo to be taken to remove the theatre of war from the north of Germany by treaties between France and thofe princes for whom the king of Pruffia might interpofe.

241 Treatment of the Republic by foreign powers.

During the fame month of April, the French Republic was acknowledged by the king of Sweden; and Baron Stael his ambaffador was received at Paris with great folemnity. In the month of May a fecond treaty with Pruffia was concluded. It chiefly regarded the line of neutrality. It is worthy of remark, that thefe treaties contained fecret articles which were to be revealed only to a felect committee. By authorifing this mode of procedure, the Convention fufficiently demonftrated its refolution, that no form of popular government to be adopted in France fhould ftand in the way of the national aggrandifement. The Swifs cantons now followed the example of Sweden, and acknowledged the French Republic. A treaty of peace with Spain was alfo concluded at Bafle on the 22d of July. France, on this occafion, relinquifhed all the conquefts fhe had made in the territory of that country, and reftored the ancient frontier. She received in return all the Spanifh part of the ifland of St Domingo. The Dutch Republic was included in this treaty; and France agreed to accept of the king of Spain's mediation in favour of Portugal and the Italian princes.

242 Death of Louis XVII.

On the 9th of June, the Dauphin, fon of the unfortunate Louis XVI. died in the prifon of the Temple, where he had been confined, along with his fifter, fince the executions of his father, mother, and aunt. His death, which was probably produced by difeafes arifing from long confinement, if not by more unjuftifiable means, excited in the French nation fuch a degree of intereft in favour of his family, that the Convention found it neceffary to liberate his fifter from imprifonment. The committee of public fafety propofed to the Emperor to exchange this princefs for the members of the Convention whom Dumourier had delivered up to Auftria, along with two ambaffadors, Semonville and Maret, who had been feized on their way to Turkey. This propofal was accepted, and the exchange took place at Bafle in Switzerland.

243 Naval fuperiority of Britain.

On the fide of Britain the war maintained its former character. The Britifh retained their fuperiority by fea, and were unfortunate in their efforts on the continent. On the 14th of March the Britifh fleet in the Mediterranean, under Admiral Hotham, engaged the French fleet, and took two fail of the line, the Ca-Ira and the Cenfeur; but as the French fleet, four days before the engagement, had captured the Berwick, a Britifh fhip of the line, when detached from the fleet, and as the Illuftrious, another Britifh fhip of the line, was fo feverely injured in the action that fhe run afhore and was loft at Avenza, the fubftantial lofs on both fides was nearly equal. On the 23d of June another Britifh fleet under Lord Bridport attacked the French off Port L'Orient, and took three fhips of the line, the reft of the fleet efcaping into that port.

This evident fuperiority of the Britifh fleet in every conteft, induced the government to take advantage of the command which it had of the fea, to give affiftance to the French Royalifts in the weftern departments. Thefe Royalifts, hitherto unaffifted by foreign powers, had, by repeated defeats, been reduced very low. The Convention had at laft offered them a treaty, which was accepted and figned at Nantes on the 3d of March, on the one fide by deputies from the Convention, and on the other by Charette, Sapineau, and other chiefs of the infurgents of La Vendée, and by Cormartin, as reprefenting the party called *Chouans* or Night Owls. Stofflet, another chief, held out for fome weeks longer; but at laft, on the 20th of April, he too was under the neceffity of fubmitting by treaty to the Republic.

244 Expedition to Quiberon Bay.

In a fhort time, however, the hopes of the Royalifts were revived by the countenance of the Britifh government, and thefe treaties were ill obferved. In the beginning of June the Britifh expedition was ready to fail for the French coaft. The troops to be employed confifted of emigrants in the pay of Great Britain, and many of them had been prifoners of war, who now agreed to join the royal caufe. The command during the voyage, and the felection of the place of landing, were intrufted to the Count D'Hervilly. The command on fhore was given to Puifaye, who had been employed under the Girondifts in the military fervice of the Republic, but had now become a royalift. The Count de Sombreuil was afterwards fent to join them with a fmall reinforcement.

On the 25th of June the expedition arrived in the Bay of Quiberon, and on the 27th 2500 emigrants made good their landing, after difperfing a fmall party of republican troops. The emigrant army foon after diftributed itfelf into cantonments along the fhore, and gave arms to the inhabitants of the country, who appeared to receive them with joy. It was foon found, however, that the Chouans, though well qualified for a defultory warfare, could not be of much ufe to regular troops. They had little fubordination. They were eafily difperfed, and never fought unlefs every advantage was on their fide. When it was found that their unfteady aid could not be depended on, a refolution was taken to withdraw the emigrant army within the peninfula of Quiberon. The fort of that name was taken on the 3d of July. Its garrifon confifted of five or fix hundred men, and it was now occupied by the emigrants. A republican army, in the mean time, under General Hoche, advanced, and attacked all the pofts that had been left without the peninfula. Thefe were fpeedily taken. The emigrants and Chouans efcaped into the boats of the Britifh fleet, or fled under the cannon of the fort of Quiberon. The republicans then began to conftruct formidable works on the heights of St Barbe, at the entrance of the peninfula. To prevent their operations, a fally was made from the fort on the 7th of July; but without fuccefs. On the 15th, another fally was attempted in greater force. The whole

whole troops in the peninfula amounted to about 12,000, including Chouans. Out of thefe a detachment of 5000 was fent to attack the heights of St Barbe. The republicans were entrenched in three camps. The two firft of thefe were eafily taken, and the detachment preffed eagerly forward to attack the third. But here a mafked battery opened upon them with grape fhot. A dreadful carnage enfued; and very few of the detachment could have efcaped, had not the fire of the Britifh fhips foon compelled the republicans to defift from the purfuit.

245 Its failure.

It now became obvious that the expedition muft ultimately fail. Defertion became extremely common among the emigrants. Thofe men in particular who had been prifoners of war, and received their liberty on condition of joining the expedition, feized every opportunity of going over to their countrymen; and a correfpondence feems even to have been eftablifhed between the republicans and the difcontented troops in the fort of Quiberon. On the evening of the 20th of July, the weather was extremely tempeftuous, which produced a fatal fecurity in the emigrant army. Sufpicious patroles were remarked; but as they repeated the watchword for the night, they were allowed to pafs. The republican troops were conducted in filence along an unguarded quarter of the fhore, till they were enabled to furprife one of the pofts of the garrifon, where they found the artillery men faft afleep. Their matches were feized, and the lanthorn intended to give the alarm to the Britifh fleet was extinguifhed. The fort was fpeedily in confufion. Some regiments threw away their arms, and went over to the republicans; others even maffacred their own officers. A confiderable number, however, maintained a violent conflict for fome time before they furrendered. Puifaye efcaped on board the fleet. The Count de Sombreuil was taken; and this accomplifhed young man was foon after put to death, along with the other emigrant officers and all the Chouans that were found in the fort. The bifhop of Dol was alfo put to death, with his clergy who accompanied him; but many of the private foldiers of the emigrant army made their peace with the republicans, by pretending they had been compelled to engage in the expedition.

The Britifh fleet, with tranfports and troops, ftill hovered upon the French coaft, and made an unfuccefsful attempt upon the ifland of Noirmoutier. In confequence of the feafon of the year, however, it returned home in December, after evacuating a fmall ifland called *L'Ifle Dieu*, which the troops had for fome time occupied.

246 Succeffes of the French in Germany.

On the fide of Germany the fortrefs of Luxembourg furrendered on the 7th of June, after having been in a ftate of blockade fince the preceding campaign. The French were now in poffeffion of the whole left bank of the Rhine excepting the city of Mentz, which they attacked in vain, becaufe the Auftrians could at all times throw fuccours into it from Fort Caffel on the oppofite bank of the river. Finding the capture of Mentz impoffible in thefe circumftances, the French refolved to crofs the Rhine to inveft the city on all fides. The enterprife, however, was delayed for fome time, till the refult of the Britifh expedition to Quiberon fhould appear. In the month of Auguft, General Jourdan forced the paffage of the Rhine at Duffeldorf, at the head of what was called the army of the Sambre and Meufe. After driving before him three Auftrian pofts upon the Lahn, he croffed the Mein, and completely invefted Mentz and Caffel. Pichegru, in the mean time, croffed the river, with the army of the Rhine and Mofelle, near Manheim, of which city he immediately took poffeffion. But the French generals foon found their forces inadequate to the undertaking in which they were engaged. A confiderable detachment of Pichegru's army, after driving the Auftrians under General Wurmfer from a poft of fome importance, began to plunder, and went into confufion. The Auftrians being informed of this circumftance, returned to the charge, and defeated the French. General Clairfait alfo, having violated the line of neutrality, came upon the rear of Jourdan's army, and took a confiderable part of his artillery. Both the French generals now retreated. Jourdan was rapidly purfued by Clairfait till he returned to Duffeldorf, where he maintained his ground. Pichegru recroffed the Rhine near Manheim, leaving a garrifon of 8000 men in that city. The Auftrians advanced in all directions. Manheim was taken after a vigorous fiege. The French were driven from the neighbourhood of Mentz. The Palatinate became the theatre of war, and the Auftrians feized the country called the *Hundfruck*, fouth of the Rhine as far as Landau and Treves. After various engagements, in which little more ground was loft or won, the two parties entered into an armiftice for three months. 247 They receive a check.

On the 28th of Auguft a treaty of peace was concluded between the French Republic and the Landgrave of Heffe Caffel, on condition that he fhould lend no more troops to Great Britain for the profecution of the war. It is not a little fingular, that peace was concluded with the Elector of Hanover at this period upon fimilar terms. The Duke of Wirtemberg, and fome other princes of the empire, alfo began to treat; but the negociations were broken off in confequence of the reverfe of fortune now experienced by the French. 248 Treaties with German princes.

The Directory, however, refolved to continue the war with vigour, and vaft preparations for the approaching campaign were made during the winter. The Mountain party being once more poffeffed of power, its members exerted themfelves with their ufual energy. Such, however, was the turbulent character of thefe men, that they could not long fubmit peaceably to any government, and foon became weary of that Directory whom they themfelves had eftablifhed. They held clubs in all quarters, and were continually difturbing the public tranquillity. For fome time the government fupported them. The Parifians, after the 5th October, no longer dared to avow openly their diflike to the Jacobins; but they were underftood to exprefs this fentiment by wearing green filk cravats, and by applauding with much vehemence at the public fpectacles the air called *Le Reveil du Peuple*. The Directory now prohibited, by an edict, as tokens of royalifm, the wearing of green cravats, or the performing at any of the theatres the air now mentioned, though the fentiments it contained were entirely republican. The Directory alfo ordered in its ftead, that the Marfeillois hymn, and other popular fongs, fhould be performed every evening at all the theatres. The Parifians fhewed their difapprobation of the Directory by maintaining a profound filence during the performance of thefe fongs, 1796. 249 Ridiculous conduct of the Directory.

French Revolution, 1796.

ſongs, which had never failed till that period to excite burſts of applauſe. The Directory ſoon became aſhamed of this ridiculous conteſt, and in a few weeks recalled their edict. Indeed they found it impoſſible to give countenance for any long period to the reſtleſs and innovating ſpirit of the Jacobins, who continually wiſhed and attempted to return to revolutionary, that is, to violent meaſures againſt their antagoniſts. In the ſouth, in particular, the preſent ſupremacy of the Jacobins produced very pernicious effects. Freron, who had deſerted them after the death of Robeſpierre, and became one of their moſt violent adverſaries, thought fit to return to their party before the 5th October, and was ſent to Toulon with full powers of adminiſtration. Here he diſmiſſed the municipality that had been elected by the people, reſtored the Jacobin clubs, and proceeded to impriſon all ſuſpected perſons, as in the days of Robeſpierre. Theſe meaſures produced a violent reaction on the part of the enemies of the Jacobins. Aſſaſſinations became frequent, and many perſons began to leave the country. The Directory was alarmed by the many complaints againſt the Jacobins or terroriſts that came from all quarters, and reſolved to aim at popularity by deſerting a ſet of men who could not be prevailed upon to act with moderation. Freron was recalled from Toulon, and more manageable men were ſought out to replace the more violent Jacobins, who were in general diſmiſſed from the ſervice of government.

250 Meaſures taken againſt the Jacobins.

The Directory proceeded farther, and acknowledged, by a public reſolution, that its confidence had been abuſed. The miniſter of police was ordered to remove from Paris the members of former revolutionary tribunals, and others who now acted as leaders of the Jacobins, or *anarchiſts* as they were called. A body of troops, amounting to 10,000 men, called the *legion of police*, that had acted againſt the Pariſians on the 5th October, and was now devoted to the Jacobins, was ordered by the Directory, with the authority of the legiſlature, to join the armies on the frontiers. Theſe men refuſed to obey the order; but they were reduced to ſubmiſſion by ſome troops that had been brought to the neighbourhood to provide againſt ſuch an event. The more violent Jacobins were enraged, but not intimidated, by theſe meaſures, and began to organize a plot for the overthrow of the Directory and of the majority of the councils, who had now deſerted them. They were not prepared for action, however, before the month of May, and by that time their deſigns were diſcovered and counteracted. On the 10th of that month the guards were increaſed, and bodies of cavalry ſtationed around the Luxembourg and the Thuilleries. The Directory at the ſame time informed the Council of Five Hundred, by a meſſage, that a dreadful conſpiracy was prepared to burſt forth on the following morning. At the ſound of the morning bell, which is every day rung, the conſpirators were to proceed in ſmall parties of three or four men to the houſes of ſuch perſons as they had marked out for deſtruction. After aſſaſſinating thoſe perſons, the whole parties were to unite, and to act againſt the Directory, whoſe guard they apprehended they could eaſily overpower. The conſpirators had appointed a new Directory and a new legiſlature, to conſiſt of the moſt violent of their own party. Among the leaders of this conſpiracy, who were now arreſted by order of the Directory, was Drouet the poſtmaſter of Varennes, whom we formerly mentioned as having arreſted the unfortunate Louis XVI. when attempting to eſcape to the frontiers. Along with him were Babeuf, Antonelle, Pelletier, Gaudet, Julien, General Roſſignol, Germain, D'Arthe, Laignelot, and Amar, who had been a member of the committee of general ſafety along with Robeſpierre. Vadier and Robert Lindet were alſo engaged in the conſpiracy, but they made their eſcape. Drouet alſo eſcaped by the connivance of the Directory, as was generally underſtood; but the reſt of the conſpirators were removed for trial to the high national court at Vendome, where they were condemned. At the period of their removal thither, a new attempt was made by their party for their reſcue. About 600 men entered the camp at Grenelle near Paris, and endeavoured to prevail with the ſoldiers to join them in an inſurrection. This attempt was altogether unſucceſsful. A few of the inſurgents were killed, and the reſt fled.

These defeats of the Jacobins, and the diſcredit under which they were again brought, encouraged the moderate party in the two legiſlative councils to attempt to repeal the laſt decrees of the Convention, which had at once granted them an amneſty, and confirmed all the laws which, by confiſcating the property of emigrants, excluded their relations from the ſucceſſion. The diſcuſſion laſted many days; but the reſult was, that the law with regard to emigrants remained on the former footing; and the only point which the moderate party were yet able to carry was a modification of the decree to this extent, that thoſe terroriſts were declared incapable of holding public offices who owed their ſafety to the amneſty. 251 Moderate party.

The ſtate of the finances now began to occupy the French government in a very ſerious manner. During the government of Robeſpierre, while the credit of the aſſignats was preſerved by the influence of terror, or by the ſale of the church lands, and the property of emigrants, little attention was beſtowed upon this ſubject. When money was wanted, more aſſignats were fabricated; and as few or no taxes were demanded from the people, no enquiry was made about the public expenditure. But when the boundleſs extravagance of the agents of government had loaded the circulation with aſſignats till they became of little or no value, it became a very difficult queſtion how the public ſervice was hereafter to be ſupported. A new paper currency, called *reſcripts*, was firſt adopted. Theſe were orders on the treaſury for caſh, payable at certain periods. But their credit ſoon paſſed away, as the treaſury had no means of fulfilling its engagements. The Directory complained very bitterly, in a meſſage to the Councils, of its diſtreſſes, and of the want of funds to carry on the approaching campaign. In conſequence of this meſſage, a law was paſſed, on the 25th of March, authoriſing the ſale of the remainder of the national domains for the price that had been fixed upon them at an early period of the revolution, amounting to about twenty-two years purchaſe. A new paper currency, called *mandats*, was to be received in payment. But the credit of government was now gone. The mandats inſtantly loſt in all private tranſactions one-fourth of their value, and they ſoon fell ſtill lower. This, however, produced a great demand for national property, 252 Diſtreſſed ſtate of the finances.

French Revolution, 1796.

perty, which was thus about to be fold far below its value. To prevent this effect, the legiflature broke its engagements, and decreed, that one-fourth of every purchafe fhould be paid, not in mandats, but in cafh. This decree put a ftop both to the fale of national property and to the circulation of mandats.

Recourfe was next had to taxation; but this was attended with much difficulty. By the war, and the violent government of Robefpierre, the French commerce had been in a great meafure ruined. Induftrious men, who poffeffed any capital, had therefore turned their attention to the cultivation of land. Many circumftances led to this. By the emigration of the nobles, and the confifcation of the church lands, the farmers were left with no landlord but the government; which, being fupported by affignats, paid little attention to any other fource of revenue. Hence they paid no rent, and fpeedily rofe into opulence. The revolutionary government, which kept the inhabitants of the towns under dreadful bondage, was fcarcely felt by the inhabitants of the country, who thus enjoyed the advantage of exciting no fufpicion in the rulers, and of paying neither rent nor taxes. The law which declared affignats to be a legal tender of payment, was a great fource of profit to the cultivators of the foil. They contrived to fell the produce of their farms only to fuch as offered them ready fpecie; while, at the fame time, they paid their rents, where the landlord had not emigrated, in affignats, which they obtained at a trifling price. Hence it ufually happened, that while the tenant enjoyed affluence, his miferable landlord was reduced to the neceffity of felling his moveables to buy a portion of the grain that grew upon his own eftate, or was tempted to fell the eftate itfelf at an undervalue, to obtain the means of emigration. By thefe and other circumftances, the whole induftry of the French nation came to be directed towards agriculture. Their country was accordingly well cultivated; but as the riches of agricultural nations are not eafily fubjected to taxation, the French Directory now found it impoffible to carry on the fchemes of ambition and of conqueft, which they had already formed, without relying for refources upon the plunder of the neighbouring ftates, which fpeedily rendered their armies odious in all thofe quarters of Europe to which they penetrated.

253 Reafons of the flourifhing ftate of agriculture.

254 National Inftitute.

Amidft their preparations for the approaching campaign, the Directory attempted to increafe their own reputation at home, by eftablifhing what is called the *National Inftitute*; which is a fociety of men of letters, under the protection of the government *. Into this body were collected the moft celebrated literary characters in the nation that had efcaped the fury of the Mountain Party. Among thefe were La Place, Lalande, Fourcroy, Berthollet, Volney, Dolomieu, and others, well known throughout Europe. The firft public meeting of the Inftitute was held, with great fplendour, on the 4th of April, in the hall of the Louvre, called the *Hall of Antiques*. The ambaffadors of Spain, Pruffia, Sweden, Denmark, Holland, America, Tufcany, Genoa, and Geneva, were prefent. The members of the Directory attended in their robes, and their prefident made a fpeech of inftallation, declaring the determination of the executive power to protect and encourage literature and the arts. Dufaulx, the prefident of the Inftitute, replied, in a fpeech in which he declared the refolution of the members to labour to give luftre to the republican government by their talents and productions. Fifteen hundred fpectators applauded the fpeeches with enthufiafm, and vainly imagined that all the evils of the revolution were terminated, and that their country was now entering upon a career of unexampled glory and profperity.

* See INSTITUTE, *Suppl.*

255 Overtures of the Britifh government

At this period the Britifh government made an approach towards a negociation with France. On the 8th of March Mr Wickham, the minifter plenipotentiary to the Swifs Cantons, tranfmitted to Barthelemy, ambaffador from the French Republic to the Helvetic body, a note containing three queftions: Whether France would be difpofed to fend minifters to a congrefs to negociate peace with his Britannic Majefty and his allies? Whether France would be difpofed to communicate the general grounds on which fhe would be willing to conclude peace, that his Majefty and his allies might confider them in concert? and, laftly, Whether France would defire to communicate any other mode of accomplifhing a peace? The note concluded with a promife to tranfmit to the Britifh court whatever anfwer fhould be returned; but declared, that Mr Wickham was not authorifed to enter into any difcuffion upon thefe fubjects.

256 Infolently rejected by the Directory.

On the 26th of the fame month Barthelemy returned an anfwer in name of the French Directory. This anfwer began by complaining of infincerity in the propofal made by the Britifh court, feeing its ambaffador was not authorifed to negociate, and that a congrefs was propofed, which muft render negociation endlefs. It proceeded to ftate the ardent defire of the Directory for peace; but afferted, that it could liften to no propofal for giving up any territory that had been declared by the conftitutional act to form a part of the Republic (alluding to the Auftrian Netherlands); declaring, however, that other countries occupied by the French armies, and political or commercial interefts, might become the fubject of negociation. Upon thefe points the Directory declared its readinefs to receive reafonable propofals.

To this anfwer no reply was fent; but the Britifh court publifhed a note, of which copies were prefented to the foreign minifters refiding at London; and in it the fpirit of the Directors anfwer was complained of, and alfo the refufal even to negociate about the retention of foreign territory, under pretence of an internal regulation. It was added, with truth, that while fuch difpofitions were perfifted in, nothing was left but to profecute a war equally juft and neceffary; but that, when more pacific fentiments fhould be manifefled, his Majefty would be ready to concur with his allies in taking meafures for eftablifhing a juft, honourable, and permanent peace.

The French Directory had fucceeded, during the winter, in reducing the weftern departments into fubjection. The emigrant expedition from England had induced the royalifts once more to try the fortune of war; but, after various defeats, their leaders, Charette and Stofflet, were taken, and put to death on the 29th of March, and the infurgents were fuppreffed in all quarters. The French government being thus left without an enemy at home, was enabled to make great efforts on the frontiers. The military force of the Republic was divided into three armies. On the Lower Rhine, the army of the Sambre and Meufe was chiefly ftationed about Duffel.

257 French armies.

French Revolution, 1796. Duſſeldorf and Coblentz, and was commanded by Jourdan. Moreau commanded the army of the Rhine and Moſelle, in the room of General Pichegru, who had been diſmiſſed from his command. This army was ſtationed on the Upper Rhine, and from Landau to Treves. The third and laſt army was ſtationed on the coaſt of Italy, from Nice towards Genoa, and now received Bonaparte as its commander. The name and the actions of this man muſt hereafter fill ſo large a ſpace in the detail of this eventful period, that it is neceſſary to pay ſome attention to his perſonal hiſtory.

258 Bonaparte. A Corſican gentleman, a lawyer by profeſſion, but who had appeared in arms under the celebrated Paoli in defence of the independence of his native iſland, was the father of Napolone Bonaparte. Napolone was born at Ajaccio in 1767; aad by the intereſt of M. de Marboeuf, the French governor of the iſland, he was placed for his education at the celebrated military academy of France (*Ecole Militaire*), which has produced ſo many accompliſhed men. At a very early period of life he preſented himſelf as candidate for a commiſſion in the artillery, and was ſucceſsful, being the 12th on the liſt out of 36 victorious candidates. In conſequence of this event he ſerved two or three years in the French army as a lieutenant in the regiment of La Fere. Bonaparte having riſen to the rank of Captain of artillery, returned to Corſica after the revolution, and was there elected lieutenant-colonel of a corps of Corſican national guards. Here he formed a connection, which had nearly proved fatal to him, with General Paoli, the friend of his father. He reſented the treatment which Paoli received from Robeſpierre's government, and entered ſo far into his intereſts as to write the remonſtrance, which was tranſmitted by the municipality to the Convention, againſt the decree which declared the general an enemy to the Republic. In conſequence of this, a warrant was at one time iſſued for his arreſt by the commiſſioners of the Convention. He made his peace, however, on this occaſion; and reſolved to adhere to the intereſts of France, in oppoſition to Great Britain, which at this period formed the deſign of taking poſſeſſion of Corſica. He embarked with the other members of his family for France, and arrived there at the time when Lord Hood was in poſſeſſion of Toulon. Salicetti, a deputy from Corſica to the Convention, introduced him to Barras, who was now ſuperintending the ſiege of Toulon. Here Bonaparte was advanced to the rank of general of artillery; and, under Dugommier, directed the attack of the various fortified poſts around the city. He was afterwards employed for a ſhort time againſt the royaliſts in the weſt of France; and we have already mentioned, that he was at the capital, and aſſiſted Barras in the conteſt between the Convention and the Pariſians on the 5th October. Hence he was regarded with diſlike by the moderate party, and repreſented as an unprincipled adventurer, brought forward to ſupport the terroriſt faction. He had mauy enemies, therefore, at the commencement of his career, and his character was treated with much freedom. The ſcandal of the times went ſo far as to aſſert, that he owed his preſent preferment, not ſo much to any talents he had yet had an opportunity to diſplay, as to his marriage with Madame Beaucharnois, a beautiful French woman whom Barras had taken under his protection.

The French army of Italy amounted at this time to 56,000 men. Bonaparte at his arrival found it ill equipped, and the troops mutinous for want of pay and neceſſaries. He addreſſed them, however, in the true ſtyle of military enterpriſe, "If we are to be vanquiſhed, we have already too much; and if we conquer, we ſhall want nothing;" and ordered them to prepare for immediate action. His opponents, however, anticipated him in the attack. The Auſtrians employed in the defence of Italy, under General Beaulieu, are ſaid to have more than equalled the French in numbers. To theſe were united the King of Sardinia's army, under Count Colli, of 60,000 regular troops, beſides the militia of the country, which was now embodied, and a ſmall body of Neapolitan cavalry, amounting to about 2500 men. General Beaulieu began the campaign, on the 9th of April, by attacking a poſt called Voltri, which the French poſſeſſed, within ſix leagues of Genoa. They defended themſelves till the evening, and then retreated to Savona. Next morning Beaulieu, at the head of 15,000 men, preſſing upon the centre of the French army, was completely ſucceſsful till one o'clock afternoon, when he reached a redoubt at Montennote, which was the laſt of their entrenchments. This redoubt contained 1500 French. Their commander, Rampon, prevailed with them, in a moment of enthuſiaſm, to ſwear that they would not ſurrender; and the conſequence was, that they arreſted the progreſs of Beaulieu for the remainder of the day. During the night, Bonaparte ſtationed his right wing under La Harpe, a Swiſs exile, in the rear of the redoubt of Montenotte, which ſtill held out, while he himſelf, with Maſſena, Berthier, and Salicetti, advanced by Altara, to take the Auſtrians on their flank and rear. Beaulieu, in the mean time, had received powerful reinforcements, and on the morning of the 11th renewed the attack on the French under La Harpe; but Maſſena ſoon advancing upon the flank of the Auſtrians and Sardinians, they gave way on all ſides. Two of their generals, Roccavina and Argentau, were wounded. They loſt 2500 priſoners, and were purſued beyond Cairo, of which the French took poſſeſſion on the following day.

French Revolution, 1796.

259 Takes the command of the army of Italy.

260 His ſucceſs.

On the 13th at day-break, the defiles of Mileſimo, were forced by the French General Augereau; and, by a ſudden movement, General Provera, a knight of the order of Maria Thereſa, at the head of 1500 Auſtrian grenadiers, was ſurrounded; a circumſtance which proved not a little embarraſſing to the French army. For this reſolute officer, inſtead of ſurrendering, inſtantly withdrew to a ruined caſtle on the top of the mountain, and there entrenched himſelf. Augereau brought up his artillery, and ſpent many hours in attempting to diſlodge him. At laſt he divided his troops into four columns, and endeavoured to carry Provera's entrenchments by ſtorm. The French loſt two generals, Banel and Quenin, and Joubert was wounded in this attempt, which proved unſucceſsful. Provera paſſed the night in the midſt of the French army, which had been prevented by his obſtinate reſiſtance from coming to battle. On the 14th the hoſtile armies faced each other, but a diviſion of the French troops was ſtill occupied in blockading General Provera. The Auſtrians attempted to force the centre of the French, but without ſucceſs. Maſſena, in the mean time, turned the left flank of their left wing near the village of

Dego;

French Revolution, 1796.

Dego; while La Harpe, with his division in three close-columns, turned the right flank of the same wing. One column kept in awe the centre of the Austrians, a second attacked the flank of their left wing, while the third column gained its rear. Thus was the left wing of the combined army completely surrounded and thrown into confusion. Eight thousand men were, on this occasion, taken prisoners, and General Provera at last also surrendered.

These victories were not gained over a timid or an inactive adversary. On the morning after his fatal defeat at Millesimo, Beaulieu made one of those spirited efforts which often retrieve and alter the fortune of war. At the head of 7000 chosen Austrian troops he attacked, at day-break, the village of Dego, where the French reposed in security after their success. He took the village; but the French having rallied under General Massena, spent the greater part of the day in attempting to retake it. They were thrice repulsed, and one of their Generals, Causse, was killed. Towards evening, however, Bonaparte in person having brought up reinforcements, the post was retaken, and the Austrians retired with the loss of 1400 made prisoners.

Bonaparte had now thrown himself between the Austrian and Sardinian armies. By the possession of the strong post of Dego, his right was secured against the efforts of Beaulieu, while he was enabled to act with the mass of his force against the Piedmontese troops. His enterprises in this quarter were facilitated by the exertions of Augereau, who had opened a communication with the valley of the Tanaro, where Serrurier's division was approaching the town of Ceva, near which the Piedmontese had an entrenched camp defended by 8000 men.

On the 16th Augereau attacked the redoubts which covered this camp, and took most of them; which induced the Piedmontese to evacuate it during the night, and on the 17th Ceva was entered by Serrurier. Count Colli now retreated to cover Turin; making choice, however, of the strongest posts, and fighting in them all. He was able, on the 20th, to repulse Serrurier; but on the 22d Bonaparte, still pressing on the Piedmontese general, defeated him near Mondovi, and entered that place. The retreating army next endeavoured to make a stand, with its head quarters at Fossano, and its wings at Coni and Cherasco. On the 25th Massena advanced against Cherasco, which was speedily evacuated. Fossano surrendered to Serrurier, and Alba to Augereau.

261 Armistice with Sardinia succeeded by

Previous to these last movements, however, Count Colli, on the 23d of April, had written to Bonaparte, requesting an armistice, to allow the King of Sardinia an opportunity of negociating a peace. The French army was now within 26 miles of Turin; and that prince saw himself suddenly reduced to the necessity of standing a siege in his capital, or of accepting such terms as the conqueror might think fit to impose. Bonaparte granted an armistice, on condition that the three fortresses of Coni, Ceva, and Tortona, should be delivered up to him, with their artillery and magazines, and that he should be allowed to cross the Po at Valentia. The armistice was signed on the 29th, and it was followed by a formal treaty with the French Republic, which was concluded at Paris on the 17th of May. The conditions imposed by this treaty upon the King of

262 A formal treaty.

Sardinia were humiliating and severe. He gave up to France for ever the duchy of Savoy, and the counties of Nice, Jenda, and Breteuil. He gave an amnesty to all his subjects that were prosecuted for political opinions. He agreed that the French troops should have free access to Italy through his territory; and, in addition to the fortresses surrendered by the armistice, he gave up those of Exiles, Susa, Brunette, Assiette, Chateau Dauphin, and Alexandria, to be possessed by the French during the war; and they were authorised to levy military contributions in the territory occupied by them. He agreed to erect no fortresses on the side of France, to demolish the fortresses of Brunette and Susa, and to disavow his disrespectful conduct towards the last French ambassador.

In the mean time the French army advanced towards the Po. Beaulieu was deceived by the arcicle in the armistice; which stipulated, that the French should be allowed to cross that river at Valentia, and made all his preparations for resistance in that quarter. Bonaparte laboured, by several evolutions, to confirm this error; and while the Austrian general waited for him near Valentia, in various well fortified positions, he advanced hastily into Lombardy, and had proceeded sixty miles down the river to Placentia, where he arrived on the 7th of May, before the direction of his march was discovered. He immediately seized whatever boats or other craft he could find, and affected his passage without difficulty, there being only a small party of Austrian cavalry accidentally on the opposite bank, and they fled at his approach. Beaulieu in the meanwhile had sent, when too late, a body of 6000 infantry and 2000 cavalry, to prevent if possible the French from passing the river; but Bonaparte, now on the same side of the river with themselves, met and defeated them on the 8th at the village of Fombio. Another body of 5000 Imperialists, advancing to the assistance of those at Fombio, was met at Codogno, and repulsed by General La Harpe; but this officer was killed on the occasion. On the 9th Bonaparte granted an armistice to the Duke of Parma, on condition of his paying a contribution of 2,000,000 of French money, and delivering 10,000 quintals of wheat, 5,000 quintals of oats, and 2,000 oxen, for the use of the army. This prince also agreed to deliver up 20 of his best paintings, to be chosen by the French. This last stipulation was no sooner known in France, than many men of letters and artists remonstrated against it as both impolitic and useless. They contended, that it would render the French Republic odious to all Italy, without producing any advantage to compensate this evil, as the progress of the arts could not be promoted by removing their best productions from the scenes in which they originated. But the Directory was too much occupied by views of national aggrandisement to listen to considerations of this kind, and similar stipulations were ordered to be inserted in every future treaty; by which means the most valuable curiosities of Italy were gradually transferred to the French capital.

263 Armistice with the Duke of Parma.

Beaulieu, now driven from the Po, crossed the Adda at Lodi, Pizzighitone, and Cremona. He left some troops, however, to defend the approaches to Lodi. The advanced guard of the French attacked these on the 10th, and drove them into the town; which was entered in such close pursuit, that the Imperialists, on leaving

French Revolution, 1796. ving it, had not leifure to break down the bridge over the Adda. At the other end of the bridge the Imperial army was drawn up, and thirty pieces of cannon defended the paffage. The French generals, after a confultation, agreed that it could not be forced. But Bonaparte having demanded of his grenadiers if they were willing to make the attempt, they applauded the propofal, and he formed them into a clofe column. Taking advantage of a cloud of fmoke which iffued from the hoftile artillery, they rufhed along the bridge, which was about 100 yards in length, and were at the middle of it before they were difcovered. Here a general difcharge from the Auftrians deftroyed 700 men. The French column hefitated, and the carnage became terrible; but Maffena, Berthier, Dallemagne, Cervoni, Lafnefs, Dupat, and other officers, flying to the head of the column, urged on the foldiers, and preffing forward, broke into the ranks of the Imperial army, which immediately gave way, and fled in all directions. This exploit has been much celebrated. The intrepidity of the troops by whom it was accomplifhed is unqueftionable; but how far the leader who urged them to fuch an enterprife is entitled to approbation may well be doubted. He had paffed the Po with fcarcely the lofs of a man. The Adda is a very inferior ftream, which has fords both above and below the town of Lodi. The river was actually croffed at one of thefe by Augereau with the cavalry, during the attack upon the bridge. With the delay of one day therefore the paffage might have been effected without difficulty by the whole army, and there was no adequate motive to juftify the lavifh expenditure of blood which was here made; for the French army no longer preffed forward in purfuit of Beaulieu, but, after the furrender of Pizzighitone and Cremona on the 12th, returned upon Pavia and Milan on its left (A). Thefe places opened their gates without refiftance, though the citadel of Milan held out for a fhort time.

264 Victory at Lodi.

It would feem that, in the original plan of Bonaparte's campaign, the utmoft expected from his efforts was to gain fuch an afcendancy in Italy as might induce the princes and ftates of that country to defert the coalition againft France, which all of them affifted with money and provifions, if not with troops. To accomplifh this object, though he fent Maffena in purfuit of Beaulieu as far as Verona, yet he himfelf now turned afide into Modena and the territories of the Pope. He took Ferrara, Bologna, and Urbino; and at laft granted an armiftice to his holinefs and the Duke of Modena, on the ufual conditions of large contributions of money, paintings, and curiofities. From the Pope he farther exacted the ceffion of the legations of Bologna and Ferrara, and poffeffion of the citadel of Ancona. His march into the Roman territory fo alarmed the Neapolitan cabinet, that it now folicited peace; and Bonaparte granted an armiftice, without attempting to add to it the humiliating conditions to which the other Italian ftates were fubjected. From the territories of the Pope, Bonaparte haftily advanced with a body of troops to Leghorn, in the neutral ftate of Tufcany, under pretence of driving out the Englifh, whofe property there he confifcated. By thefe meafures the tafk affigned to Bonaparte was completed by the time the campaign upon the Rhine was begun. Mantua was ftill indeed in the hands of the Imperialifts, but it was blockaded, and all Italy was now fubmiffive to France.

265 Its confequences.

French Revolution, 1796.

266 Succeffes of the French in Germany.

To diminifh, if poffible, the efforts of the French on the fide of Italy, the Imperialifts thought it neceffary to renew the conteft in Germany. An intimation was therefore fent to General Jourdan, that the armiftice would terminate and hoftilities commence on the 31ft of May. At this time General Wartenfleben oppofed Jourdan; and the Archduke Charles commanded the army in the Hundfruck, which covered Mentz and Manheim, and was ftationed againft Moreau on the Upper Rhine. The French began their operations with a very artful ftratagem, intended to draw the whole Auftrian force to the Lower Rhine, that Moreau might have an opportunity of fuddenly penetrating into Swabia, and confequently of carrying the war towards the hereditary territories of Auftria. For this purpofe Moreau remained quiet, while Jourdan began to act vigoroufly. On the 31ft of May his left wing, under Kleber, iffued from the lines of Duffeldorf, on the right bank of the Rhine, and, advancing towards the Sieg, defeated the Imperialifts. Thereafter they were driven fucceffively from the ftrong pofitions of Ukareth and Altenkirchen, and retreated acrofs the Lahn, Jourdan, in the mean time, having advanced with his centre and right wing, forced the Auftrian pofts on the Nahe, croffed the Rhine, formed the blockade of the fortrefs of Ehrenbreitftein, and haftened forward as if about to form the blockade or fiege of Mentz. By thefe movements the Archduke found himfelf in the hazardous fituation of having Moreau in his front, while Jourdan, with a victorious army, commanded his rear. He therefore haftily croffed the river, leaving the fortreffes of Mentz and Manheim to keep Moreau in check. Having joined the retreating army, he encountered Jourdan's advanced guard, which he compelled to retire after an obftinate conflict. Jourdan did not hazard a general engagement, but withdrew to his former pofitions, the Archduke preffing hard upon him, till he raifed the blockade of Ehrenbreitftein, and croffed the Rhine in its neighbourhood, till Kleber, on the 20th of June, entered the lines of Duffeldorf, from which he had fet out.

Thefe movements were forefeen. For the inftant that the Archduke withdrew from the Palatinate to drive Jourdan down the Rhine, Moreau afcended rapidly towards Strafburgh; fo that thefe hoftile armies feemed to be flying from each other with all poffible fpeed. On the 24th of June, Moreau effected the paffage of the river oppofite to fort Kehl. This was an enterprife of confiderable difficulty; for a fudden fwell, by covering a part of the iflands with which the river abounds, had prevented the Auftrians from being taken by furprife, as was originally intended. The entrenchments on fuch iflands as were occupied by troops were fpeedily carried by the bayonet, and 2600 French landed on the oppofite fhore, but without cavalry or artillery. Here they were expofed to the attacks of the Auftrian

(A) We think this conduct cannot be accounted for, but by the fuppofition of a very improper correfpondence between Bonaparte and the Auftrian officers.

French Revolution, 1796.

Auſtrian horſe from the camp of Wilſtedt, and to the fire of the cannon of the fort. They maintained their ground, however, and even acted on the offenſive, till the boats, which had been ſent back, returned with a reinforcement. The whole redoubts and the fort were then inſtantly taken by ſtorm, or with the aſſiſtance of ſuch cannon as had been found in the firſt redoubts at which the French arrived, and the Imperialiſts fled towards Offenburgh.

The departure of the Archduke to the Lower Rhine in purſuit of Jourdan, and the large detachments which had recently been ſent towards Italy to oppoſe Bonaparte, now enabled Moreau to enter Swabia with a great ſuperiority of force. The ſtrong military poſitions, however, which the country affords, preſented to him conſiderable difficulties. On the 26th of June he drove the Auſtrians from their camp of Wilſtedt; and on the 27th he advanced with his army, in three columns, againſt another camp of 15,000 men in front of Offenburgh. General Wurmſur ſent a ſtrong reinforcement from Manheim to the aſſiſtance of theſe troops; but having encountered two of the French columns on its way, the reinforcement was defeated, and the camp at Offenburgh was evacuated during the night. The Auſtrians made an obſtinate ſtand at Renchen, near Philipſburgh, on the 29th, but were at laſt compelled to retire with the loſs of 1200 men taken priſoners, and ſeveral pieces of cannon. On the 2d of July a diviſion of the French army, under General Laroche, ſucceeded in ſeizing the mountain Knubis, which is the higheſt point of the ridge of mountains called the Black Foreſt. On the 3d, after an obſtinate conflict, the Auſtrians were driven from the paſs of Friedenſtadt; in conſequence of which they loſt all communication with the emigrant troops under the Prince of Condé, and other Imperial troops ſtationed on the Rhine towards Switzerland. On the 6th, the left wing of the French, under Defaix, encountered the Imperialiſts at Raſtadt, where the Auſtrians, who had received ſome reinforcements from the Lower Rhine, made a very determined reſiſtance; but were at laſt compelled to give way, and to retire to Ettingen.

The Archduke Charles now arrived in perſon with his army from the Lower Rhine, where he had left Wartenſleben, but with inferior force, to oppoſe Jourdan. The French, under this general, had inſtantly reſumed the offenſive upon the departure of the Archduke. Kleber advanced from the lines of Duſſeldorf, as formerly; while the centre and right wing croſſed the Rhine near Coblentz. The poſts of Ukareth and Altenkirchen were forced, and on the 9th of July the whole of Jourdan's army croſſed the Lahn. On the 10th, Wartenſleben was defeated near this river, after great ſlaughter on both ſides, with the loſs of 500 priſoners; and the French on the 12th entered Franckfort. The ſituation of the hoſtile armies was now become extremely important. The two Imperial armies were at no great diſtance from each other, and were placed in the centre between the armies of Moreau and Jourdan. Could the Archduke, who was commander in chief, have reſiſted one of theſe armies for a ſhort time, at any ſtrong poſition, by a detachment of his troops, while he precipitated himſelf with the maſs of his force upon the other, is is probable that any farther invaſion of Germany might have been prevented. But the activity of the French generals, whoſe progreſs could nowhere be reſiſted by partial efforts, prevented the poſſibility of executing ſuch a plan. He was therefore under the neceſſity of making his final exertion for the preſent ſafety of Germany againſt Moreau at Ettingen, on the 9th of July, without having formed any junction with Wartenſleben. The battle was moſt obſtinately fought. The French were four times repulſed in their attempts to force the heights of Rollenſolhe; and it was not till they had experienced a dreadful ſlaughter that they at laſt carried the field by the bayonet.

The loſs of the battle of Ettingen compelled the two Imperial armies to retire eaſtward. After placing ſtrong garriſons in Mentz, Manheim, and Philipſburg, the Archduke retreated through Swabia towards Ulm, where his magazines were placed. At every ſtrong poſition, however, he made an obſtinate ſtand; thus endeavouring to render the progreſs of the French under Moreau as tardy as poſſible. Wartenſleben, with the other Imperial army, retired through Franconia, reſiſting Jourdan in the ſame manner. Many bloody battles were fought, of which it is here unneceſſary to give a minute deſcription. It is ſufficient to remark, that the French were long ſucceſsful in them all. They gradually preſſed forward till Moreau's army compelled the Archduke to croſs the Neckar, and afterwards the Danube, leaving the whole circle of Swabia in the rear of the French. Wartenſleben was in like manner driven through Aſchaffenburgh, Wurtzburg, Schweinfurt, and found it neceſſary to croſs the Rednitz, on the 6th of Auguſt, at Bamberg, to avoid the preſſure of Jourdan's army in his rear. This army continued to advance till its right wing, under Bernadotte, was poſted at Neumarck, with his advanced poſts at Teining, while the body of the army had driven Wartenſleben beyond the Nab, and had reached Amberg on the 22d of Auguſt. 267

Alarm throughout Germany.

Excepting a part of the mountains of Tyrol, three French armies, under Jourdan, Moreau, and Bonaparte, now occupied the whole country reaching from the frontiers of Bohemia to the Adriatic Sea. The alarm throughout Germany was extreme. The Duke of Wirtemberg obtained peace from the French on condition of paying 4,000,000 of French money. The circle of Swabia did the ſame, on engaging to pay 12,000,000 of livres, and to deliver 8,400 horſes 5,000 oxen, 100,000 quintals of wheat, 50,000 quintals of rye, 100,000 ſacks of oats, 100,000 pairs of ſhoes, and a large quantity of hay. The Margrave of Baden obtained peace on ſimilar terms. The elector of Bavaria and the circle of Franconia negociated, and offered large payments; and even the diet of Ratiſbon ſent a deputation to treat with the French generals for neutrality. The King of Pruſſia now entered into a new treaty with the French; the conditions of which were concealed, but its nature appeared in the advantage which he took of the progreſs of their arms to take poſſeſſion of certain territories in Germany, and particularly of the ſuburbs of Nuremberg, under pretence of ſome antiquated title. Spain alſo entered into a treaty offenſive and defenſive with France, which was afterwards followed up by a declaration of war again Britain. 268

Danger of the houſe of Auſtria.

The danger of the houſe of Auſtria was now very great; and had Bonaparte, inſtead of being detained in Italy, by events of which we ſhall immediately take notice,

French Revolution, 1796.

tice, been able to croſs the Tyrol by Inſpruck, and to reach the banks of the Danube, there is little doubt that the Emperor muſt have ſubmitted to ſuch conditions as the French thought fit to impoſe. Deſerted in all quarters by the members of the coalition, he ſtill, however, retained an ally in Great Britain, whoſe riches, liberally beſtowed in the form of a loan, extricated him from the preſent difficulties. Having the command of abundance of money, he was enabled to ſend one army after another to oppoſe Bonaparte in Italy, while he recruited his armies in Germany by extenſive levies, and by taking into his pay the troops of thoſe ſtates that made peace with France.

269 Maſterly conduct of the Archduke.

The Archduke, having received powerful reinforcements, reſolved to make a ſtand, on the 11th of Auguſt, againſt Moreau at Umenheim. A ſevere battle was fought during ſeventeen hours, and one of the wings of the Auſtrian army, under General Rieſe, even ſucceeded in occupying four leagues of territory in the rear of the French army; but the Archduke having received intelligence, in the mean time, that Wartenſleben could not maintain his ground againſt Jourdan, he thought it neceſſary to continue his retreat, and to adopt new meaſures. On the 17th of Auguſt he left General La Tour, with a part of his numerous army, to oppoſe Moreau, and having croſſed the Danube at Neuburg and Ingolſtadt, he marched to Wartenſleben's aſſiſtance to fall upon Jourdan with united forces. On the 23d he attacked Bernadotte at Teining, and forced him to retire towards Nuremberg. The Archduke was thus upon the right of Jourdan, while Wartenſleben was ſtationed on his front. The French general, finding his poſition dangerous, began to retreat on the 24th. From the ſtate of the finances, the French armies, at the commencement of this campaign, had been extremely ill equipped and ill paid. Hence the two armies of Moreau and Jourdan plundered, without decency or mercy, every place into which they entered. In Jourdan's army, more eſpecially, the want of diſcipline was extreme (A). Hence, when they began to retreat, loaded as they were with ſpoil, they ſuffered not leſs from the enraged inhabitants of the countries through which they paſſed, than from the military efforts of the hoſtile army. The Archduke having joined Wartenſleben, was enabled to ſend off Nauendorf with reinforcements to La Tour, who oppoſed Moreau, and, in the mean time, he continued in perſon to purſue Jourdan towards Wurtzburg. Here the French made a ſtand, on the 3d of September, and a general engagement took place. Both parties ſuffered great loſs, but more eſpecially the French, who retreated during the night. Jourdan now fled by Fuldaw to Wetzlaer. Having croſſed the Lahn, where he made ſome reſiſtance, he deſcended along the banks of the Rhine, till his army, on the 17th, reached Coblentz and Duſſeldorf, from which it had originally departed.

270 Critical ſituation of Moreau.

The ſituation of Moreau's army was now uncommonly dangerous. He maintained his poſition, however, till the 17th of September; but he was undecided in his movements, and was obviouſly at a loſs how he ought to proceed. He attempted, without ſucceſs, to withdraw the Archduke from the purſuit of Jourdan, by detaching a part of his troops towards Nuremberg. Many attacks were made upon him, but all of them without ſucceſs; and the Imperial generals at laſt gave way to him wherever he turned. Finding at laſt that Jourdan's defeat was irretrievable, and that Bonaparte did not arrive from Italy, he reſolved to retreat. He had recroſſed the Lech to prepare for this event; but now ſuddenly paſſing it again, as if determined to advance farther into Auſtria, he drove back General La Tour as far as Landſberg. Having thus obtained freedom for his future movements, he ſet out in full retreat, proceeding between the Danube at Ulm and the lake of Conſtance. La Tour, however, ſoon preſſed upon his rear. He found the paſſes of the Black Foreſt occupied by large bodies of Auſtrians and armed peaſants, while Generals Nauendorf and Petrarſch haraſſed his right flank with 24,000 men. Once more therefore he turned upon La Tour, at Biberach, on the 3d of October, with great impetuoſity, and having defeated him, took no leſs than 5000 priſoners; whom he was able to carry to France. He now continued his retreat; his right wing, under General Deſaix, keeping Nauendorf and Petrarſch in check, while the reſt of the army cleared the paſſages in front till he arrived at what is called the Valley of Hell (*Val d'Enfer*), a narrow defile, running for ſome leagues between lofty mountains, and in ſome places only a few fathoms in breadth. The centre of his army, advancing in a maſs, forced this paſſage, while the wings reſiſted the Imperial troops under La Tour and Nauendorf. After this deſperate effort he reached Fribourg on the 13th of October, and was ſoon compelled by the Archduke Charles, who had now arrived from the purſuit of Jourdan, to evacuate all his poſitions on the Swabian ſide of the Rhine, with the exception of Kehl, and a temporary fortification erected at Huningen, called a

271 His ſkilful retreat.

(A) It would be improper to interrupt our military detail with the following information reſpecting the morals of Jourdan's army at this time; which, however, it is of importance for our reader's to know. We have it from a German Count, who ſaw with his own eyes a conſiderable extent of the march and countermarch of the French through Franconia.

Almoſt every officer in Jourdan's army had a miſtreſs; and ſuch of them as by plunder could ſupport the expence, gave balls, acted plays, and exhibited every ſpecies of gaiety when the army was not in actual motion. In all this there was nothing wonderful. The ladies, however, were not unfrequently pregnant; and as nurſing would keep them from theſe aſſemblies, where their company could not be diſpenſed with by the ſoldiers of liberty, they drowned their new-born infants—*they drowned them publicly!* Our correſpondent (the Count) ſaw two of the little victims, and he heard, from unqueſtionable authority, of ſeveral more. At a place within ſix miles of Nuremberg, a Pruſſian pariſh-miniſter, who was alſo a ſort of juſtice, endeavoured to ſave one innocent, and was thrown into the river and fired at by the French, when his pariſhioners endeavoured to ſave him. He had the happineſs, however, to ſave the child, and was allowed to keep it, the mother never enquiring after it!

French Revolution, 1796.

bridge-head (*tete de pont*), though there was no bridge at that place.

The Imperial troops, in the mean time, had taken advantage of the defenceless state of the French frontier to cross the Rhine at Manheim, and to advance in various detachments to Weissemburg, Seltz, Hagenau, and almost to the gates of Strasburgh, levying contributions and taking hostages wherever they came. These detachments being now recalled, the Archduke resolved to terminate the campaign by the capture of Kehl, and of the fortification at Huningen. But this proved no easy task. As the communication with the French side of the river was open at both places, the divisions of Moreau's army did duty at them by turns. A great part of the winter was spent in fruitless attempts, on the part of the Austrians, sometimes to take them by storm, and sometimes to reduce them by the forms of regular siege. Different sallies were made by the French, and immense numbers of men were lost on both sides by the sword, and by the severity of the season. It was not till the 10th of January that the French agreed to evacuate Kehl, and the fortification at Huningen was not given up till the succeeding month.

During the invasion of Germany that has been now mentioned, and the reverses that were suffered by the French armies there, Bonaparte still continued to gain victories in Italy. The success and the wonderful fortune of this man, require that we should give some account of the arts by which he was enabled, so unexpectedly, to triumph over the most experienced military commanders of the age in which he lived. In the military art three orders of battle, or forms of drawing up an army, have been chiefly adopted by those nations whose force has principally consisted of foot soldiers.

272 Reflections on the different orders of battle.

The first form or mode consists of arranging the troops in a deep line; that is, with from 16 to 30 men placed close behind each other. This is the most ancient and the simplest order of battle. It was carried to perfection by the Greeks, under the name of the *Phalanx*; and, when the soldiers were armed with the long spear, it was extremely formidable. It left little to the skill of the general, except the choice of the ground where he was to fight, and made all to depend upon the steadiness of the troops. It was attended with these disadvantages, however, that an army thus drawn up commanded very little territory, and that if its ranks happened to be broken by unequal ground, or an uncommon effort of the enemy at a particular quarter, its parts could not easily be re-united, and it infallibly went into confusion. In modern times, this order of battle cannot be adopted with success on account of the facility with which it is broken by artillery, and the slaughter to which it exposes the troops from every kind of fire arms. The second, or modern order of battle, consists in forming a front of an immense extent, with only two or three men in depth, and usually supporting these by another, and perhaps a third equally slender line, at a considerable distance in the rear. Troops thus drawn up derive the greatest possible benefit from their own fire arms, and suffer the least loss from those of the enemy. They provide for their own subsistence by covering an immense tract of country. Their battles are not sanguinary, as they are seldom very closely engaged; and in case of a defeat, little loss is suffered, because they can scatter themselves over a wide space, as the rear protects the advanced body; and as the troops in a long line can seldom all be engaged at once, they are supported by each other in a retreat. This order of battle, however, is easily broken; and the moment the flank of an army is turned, it is under the necessity of retreating, as troops cannot speedily be brought from other quarters to face the enemy there. The last order of battle consists of dividing an army into columns of a narrow front and very great depth, and of stationing the columns at some distance from each other, with a second set of columns opposite to the intervals between the first. This arrangement is superior to the phalanx, in this respect, that it does not expose an army to disorder by inequalities of ground, by the turning of its flank, or even by the defeat of one of its parts. The celebrated Epaminondas won the battles of Leuctra and Mantinea, by forming a part of his troops, on each of these occasions, into a strong column, which, by its great depth, and the mechanical weight of its shock, broke through the Spartan phalanx. The Romans are known to have owed their military success, in a great measure, to the arrangement of their legion. It was drawn up upon the principle now mentioned; and tho' the columns were only 16 men in depth, it was confessedly superior to the phalanx. In modern times, however, this order of battle is attended with great difficulties. It must reduce an army to embarrassment with regard to provisions from the smallness of territory which is thus occupied, and it exposes the troops in an engagement to dreadful destruction from the powerful missile weapons which are now employed. In every enterprise they must instantly carry their point or be undone, as the fire of a few guns from a single battery or redoubt would exterminate them by thousands. With all its imperfections, however, this last order of battle has at times been employed by enterprising men. It was the favourite arrangement of Gustavus Adolphus; and his troops were drawn up according to it at the battle of Lutzen, where he himself was killed, while his army was victorious. The celebrated Marquis of Montrose also used it on more than one occasion, and it was now adopted in all important cases by Bonaparte.

273 The order adopted by Bonaparte.

Trusting to its success, he pushed his columns into the midst of the Austrian army at Millesimo, and fairly captured one of its wings. He ventured farther to throw himself into the centre, between the Austrian and Sardinian armies, and to vanquish the one, by acting against it with his whole troops while separated from the other. Being careless about the shedding of blood, he never hesitated to expose his whole army to utter ruin in case of a failure. The success of his battles, by enabling him to lay almost all Italy under contribution, gave him the means of maintaining the most steady and severe discipline over a well paid army. Filled with high notions of military glory, which he is said to have derived from the writings of Plutarch, he laboured to inflame, with the same spirit, the minds of his soldiers by proclamations, expressed in a very different style from the formal and more modest language of modern times. "Soldiers (said he, when he first entered Lombardy), you have rushed like a torrent from the summit of the Appenines, you have driven back and dispersed all who opposed your march. Your fathers, your mothers, your wives, your sisters, your sweethearts, rejoice in your success, and boast with pride of being related to you. But

274 His pompous proclamation.

French Revolution, 1796.

But remains there nothing more for you to effect? Shall pofterity reproach us with having found a Capua in Lombardy? But I already fee you rufhing to arms; an unmanly repofe fatigues you, and the days loft to glory are loft to your felicity. But let the people be tranquil; we are the friends of all nations, and more particularly of the defcendants of the Brutufes, the Scipios, and the illuftrious perfonages whom we have chofen as models. To reftore the Capitol, to replace with honour the ftatues of the heroes who rendered it renowned, and to roufe the Roman people, become torpid by fo many ages of flavery, fuch will be the fruit of your victories; they will form an epoch to pofterity, and you will have the immortal glory of renovating the faireft portion of Europe. The French nation, free and refpected by all the world, will give to Europe a glorious peace. You will then return to your homes and your fellow-citizens; who, when pointing to you, will fay, *He was of the army of Italy.*"

275 Marfhal Wurmfer attacked. At the commencement of the French invafion of Germany, Marfhal Wurmfer was fent into Italy to replace Beaulieu, who was removed from his command. On his arrival, he collected the wrecks of the Auftrian army, and prepared, till he fhould receive reinforcements, to confine the French within as narrow limits as poffible, by lines drawn from the lake of Garda to the river Adige. At the end of June, however, thefe lines were attacked and carried by Maffena's divifion, which induced Wurmfer to avoid farther exertion till he fhould receive an increafe of force. In the mean time Bonaparte was not a little difturbed by partial infurrections of the Italians. Soon after his arrival in Lombardy, the inhabitants of Milan and of Pavia had rifen in concert againft his troops; but they were reduced to fubjection with little bloodfhed. In the beginning of July, farther infurrections broke out in the Romagna. The infurgents eftablifhed their head quarters at Lugo, and repulfed a party of French cavalry that was fent againft them. It was not till Augereau had overcome them, on the 6th, in a battle in which he loft 200 men, that they could be fubdued. The flaughter of thefe unhappy people was very great. Their town was given up to pillage, and all found in arms deftroyed.

276 Mantua befieged. The firft part of the month of July was fpent by Bonaparte in commencing the fiege of Mantua in regular form; and towards the clofe of that month he expected its capture. In this, however, he had ill-calculated the immenfe military efforts which Auftria, aided by the money of Britain, was capable of making. Twenty thoufand troops had been fent from the Rhine, and other reinforcements were marching towards Italy from all quarters; fo that Bonaparte, inftead of being able to take Mantua, had fpeedily to defend himfelf againft the force of a fuperior army to his own, that approached to raife the fiege, and even threatened to drive him out of Italy. Wurmfer's army defcended from the Tyrol

277 Partial fucceffes of Wurmfer. in two divifions. One half of it proceeded along the eaft fide of the lake of Garda, and the other came by the weft to cut off the retreat of the French, who were thus enclofed by the Auftrians. On the 29th of July, at three o'clock in the morning, Maffena was driven from the ftrong poft of La Corona, on the eaft of the lake, while, at the fame time, 15,000 Auftrians drove the French from Salo, and afterwards from Brefcia, with all the magazines and hofpitals of Bonaparte's army. There was a fatal error, however, in the general plan of operations that had been formed by the Imperialifts. Their army united was an overmatch for the French; but they had voluntarily divided it into two parts, placing Bonaparte between them. The error was inftantly difcerned, and taken advantage of by their antagonift. On the night of the 30th, he fuddenly raifed the fiege of Mantua, and leaving a fmall body of troops to keep in check the Imperialifts on that fide, he marched rapidly weftward, and on the firft of Auguft retook Brefcia, with the magazines and hofpitals. Having the mafs of his army united, Bonaparte furpaffed his antagonifts in numbers wherever he encountered them. He prepared to attack the Imperialifts on the 3d at Salo, Lonado, and Caftiglione, but was anticipated by them. Having formed a large body of his troops into clofe columns, the Auftrians, who were not yet aware of the nature of his mode of fighting, extended their line to furround them; a movement which enabled the columns to penetrate the Imperial army in all directions, and throw it into complete diforder. The French took 4000 prifoners, and 20 pieces of cannon. The Imperial troops 278 He is defeated. were here fo completely defeated, that a confiderable divifion of them having in vain attempted to retreat by Salo, which they found occupied by the French, wandered about in fearch of a road by which to efcape; and having next day come to Lonado, they fummoned it to furrender, upon the fuppofition that the greater part of the French army had gone eaftward to encounter Wurmfer. This was actually the cafe; but it fo happened, that Bonaparte was in perfon at Lonado with only 1200 men. He was fufficiently perplexed by this accident; but having ordered the meffenger to be brought into his prefence, he threatened to deftroy the whole divifion for having dared to infult the French army, by fummoning its commander in chief to furrender. The ftratagem was fuccefsful. The Imperial officers imagined that the whole army was in the place, and immediately, with their troops, laid down their arms, to the number of 4000 men.

Such is the account of this tranfaction, which we have from the partial pen of the panegyrift of Bonaparte, who writes the hiftory of his campaigns in Italy; but we believe that the General has himfelf affigned the true reafon of his fuccefs on this occafion, and others, where fuccefs could not be reafonably expected. In one of his intercepted letters, Bonaparte informs his correfpondent, that the Auftrian armies in Italy coft him more money than his own; and indeed it is not within the compafs of fuppofition, that a body of veteran foldiers could have been intimidated to lay down their arms by fo vain-glorious a threat as this, had not their officers been corrupted by French gold and French principles. The ftratagem might have its effect upon the common foldiers, but it could not poffibly impofe upon their leaders, or upon the meffenger who fummoned Lonado to furrender.

On the 5th and 6th, Bonaparte attacked Marfhal Wurmfer, and drove him from Pefchiera and the river Mincio. On the 7th, the Auftrians were compelled to quit Verona, and to retire once more to the mountains of Tyrol. The conteft, which had lafted more than 279 Again defeated. fix days, coft the Imperialifts more than 20,000 men, upwards of 15,000 of whom were made prifoners. A part of the Emperor's troops had been levied in Gal-

 licia,

French Revolution, 1796.

licia, the part of Poland which, in the partition of that country, had been allotted to Auſtria. Theſe men ſeized the moment of defeat to quit a ſervice which they diſliked, and to go over to the French; a circumſtance which greatly ſwelled the liſt of priſoners.

It was now neceſſary for the French to commence the ſiege of Mantua anew. The garriſon in their abſence had deſtroyed their works, and carried into the place 140 pieces of heavy cannon which they had left behind them, and procured a conſiderable quantity of proviſions. The blockade was renewed; but the French, by the loſs of their artillery, were unable to proceed to a regular ſiege; and by the beginning of the month of September, Marſhal Wurmſer, having received new reinforcements, was again enabled to attempt the relief of the place. Bonaparte having information of his intended approach, left ſufficient troops to keep up the blockade, while he advanced northward with his army; and on the 4th of September drove the Auſtrians from the paſſes of St Marco and the city of Roveredo to the
280 paſs of Calliano, where they made their principal ſtand.

His maſterly conduct after a third defeat.

Here a battle enſued, in which the French took no leſs than 6000 priſoners, and entered Trent as conquerors. Upon ſuffering this defeat, Marſhal Wurmſer adopted a meaſure which cannot be ſufficiently approved of. Inſtead of retiring before the conqueror, who might have driven him to Inſpruck, and arrived at a critical moment at the Danube, where Moreau, after much heſitation, had only commenced his retreat, he ſuddenly threw himſelf with his vanquiſhed army into Baſſano, upon the flank and rear of Bonaparte, and then advanced by haſty marches towards Mantua. He attempted to make a ſtand at Baſſano on the 8th, but was defeated, and 5000 of his men were taken priſoners. He had ſtill a conſiderable body of troops however. With theſe he puſhed forward; and having fought different ſcattered diviſions of the French at Cerea, Caſtellano,
280 and Due Caſtello, he effected the paſſage of the Adige at

He enters Mantua.

Porto Legnano, entered Mantua with the wreck of his army, amounting to about 4000 infantry and 4500 cavalry. In this enterpriſe the Imperialiſts loſt altogether 20,000 men; but the effect of it was, that it fixed Bonaparte in Italy, where he was obliged to remain watching and keeping under blockade the numerous garriſon of Mantua. He hoped that its numbers would ſoon reduce it by famine to the neceſſity of a capitulation; but in this he was deceived, as the fleſh of the horſes, carried into it by Wurmſer, afforded ſubſiſtence to the troops during a very long period.

In the mean time, the fame which their countryman Bonaparte gained by theſe victories, produced in the
281 Corſicans a deſire to change the Britiſh government for

Corſica revolts from Britain, and unites with France.

that of France. They accordingly diſplayed ſo mutinous a ſpirit, that the Britiſh Viceroy thought fit to evacuate the iſland, which was no longer of any value to his government after all Italy had, in a great meaſure, ſubmitted to the French. The Imperial ſubjects in Italy alſo, along with the inhabitant of Bologna, Ferrara, and Modena, who were completely corrupted by the falſe philoſophy of the age, began now to republicaniſe themſelves under the patronage of the French general. They ſent deputies to a convention, levied troops, and aboliſhed all orders of nobility.

The Emperor ſoon ſent into the field a new army to attempt the relief of Mantua. In the beginning of November this army advanced under the command of Field Marſhal Alvinzi, who advanced towards Vizenza on the eaſt, ſeconded by General Daviduvich, who deſcended with another diviſion from Tyrol. Alvinzi had already croſſed the Piava, when he was met by the French, and compelled to repaſs that river. But Da- 282

Partial ſucceſſes of the Auſtrians.

vidovich, in the mean time, after ſeveral engagements, having ſucceeded in driving the French down the Adige towards Verona, Bonaparte was under the neceſſity of concentrating his forces. He now adopted his uſual expedient of keeping one diviſion of the hoſtile army in check, while he contended with the maſs of his forces againſt the other. He left Vaubois with ſome troops to detain Davidovich, while he advanced in perſon againſt Alvinzi, who was now haſtening towards Verona. He was met, on his way, by the Auſtrians at the village of Arcole. To ſeize this village, which could not be ſpeedily turned on account of a canal, the French were under the neceſſity of paſſing a narrow bridge in the face of the fire of the Auſtrians. They made the attempt without ſucceſs. Their officers ruſhed to the head of the column, and in vain attempted to rally the troops. Generals Verdier, Bon, Verne, and Laſnes, were carried off the field. Augereau advanced with a ſtandard to the extremity of the bridge, but nobody followed him. At laſt Bonaparte, who in the mean time had ſent Guieux with 2000 men to turn the village at two miles diſtance, haſtened to the bridge of Arcole. Seizing a ſtandard, he advanced at the head of the grenadiers, crying, "Follow your general." They accordingly followed him to within 30 yards of the bridge, when they were intimidated by the terrible fire of the Auſtrians; and their leader found it neceſſary to retire. Attempting to mount his horſe to rally the column, leſt the Auſtrians ſhould advance to the purſuit, he was thrown into a moraſs, while ſtill under the fire of the troops in the village; but here he again eſcaped, as the Auſtrians did not attempt to follow up their advantage.

The village of Arcole was taken towards the evening by Guieux, and afterwards evacuated by the French. On the following day (the 16th of November) an obſtinate conflict enſued in its neighbourhood, at which nothing deciſive was accompliſhed. On the 17th the 283

They are defeated.

Auſtrians, having preſſed impetuouſly forward upon the centre of the French army, were taken by ſurpriſe upon their flank by the left wing of the French, which had been ſtationed for that purpoſe in ambuſcade. Their left wing, however, maintained its ground till Bonaparte ſent round a party of horſe with twenty-five trumpeters to their rear, who, by the noiſe they made, induced the Auſtrians to believe themſelves ſurrounded, and to fly on all ſides in confuſion.

Here again appear evidences of treachery among the Auſtrian officers, though the battle of Arcole was the moſt ſevere which the French had yet fought in Italy, and extremely fatal to their officers, as well as to a multitude of their troops. During its continuance, Davidovich had ſucceeded in defeating Vaubois, who was oppoſed to him and Rivoli, and the blockade of Mantua was actually uncovered for a time. But Bonaparte now returned, after having driven Alvinzi acroſs the Brenta, and the poſitions of Rivoli and La Corona were retaken, and Davidovich repulſed into Tyrol. General Wurmſer, however, ſtill held out in Mantua during

French Revolution, 1796.

during the remaining part of the year; and the only fruit hitherto derived from so many victories was, that the French nation was led to look towards Bonaparte as its only invincible commander, upon whom all its hopes of conquest were to depend.

284 Negociation between Britain and France.

During these military transactions, Great Britain had entered into a negociation with France. In consequence of passports obtained from the Directory, Lord Malmesbury arrived in Paris, and began the negociation with De la Croix the minister for foreign affairs. Tho' the Directory could not decently refuse to negociate, yet they were unwilling seriously to conclude a peace with Britain. On the other hand, the British ministry have since declared that, as individuals, they actually disapproved of a peace at this time, but that they thought it necessary both to negociate, and even to conclude a treaty, if proper terms could be obtained. In judging thus, they were certainly right; for the country at large, not seeing the danger of peace, was very desirous of it, whilst a desperate faction was constantly ascribing the continuance of the war to the criminal obstinacy of the British government. The negociation which was now set on foot opened the eyes of all but those who wished to sell their country to French regicides. Lord Malmesbury proposed, that the principle of mutual restitutions should be agreed upon as the basis of the treaty. After much useless altercation, and many notes had passed upon this subject, and also upon the question, how far Lord Malmesbury could negociate for the allies of Great Britain, from whom he had received no official powers, the Directory at last agreed to the general principle of mutual restitutions, and required that the objects of these should be specified. Accordingly, the British ambassador proposed, in two memorials, that France should relinquish the Austrian Netherlands, and offered to give up the French foreign settlements in return. An offer was also made to restore a great part of the Dutch foreign possessions,

285 Suddenly broke off by the Directory.

on condition that the Stadtholder's ancient authority should be acknowledged in that country. The Directory now required Lord Malmesbury to present the ultimatum of his conditions within twenty-four hours. On his complaining of this demand, he was informed, on the 19th of December, that the Directory would agree to no conditions contrary to the French constitution; and it was added, that his farther residence at Paris was unnecessary!

286 Cape of Good Hope with a Dutch squadron, taken by the British.

During this year, Great Britain retained her usual superiority by sea. A British squadron, under Admiral Elphinston, had taken possession of the Dutch settlement at the Cape of Good Hope, on the 16th of September 1795. This settlement the Dutch wished eagerly to recover; and for this purpose they advanced money to enable the French to fit out a squadron to co-operate with them in an attack upon it. The French government took the money, but the squadron was never equipped. The Dutch themselves this year sent a squadron of seven ships of war, under Admiral Lucas, to attempt to reconquer the Cape; but being no match for the British squadron, and being likewise caught between two fires, without the possibility of escaping, the Dutch fleet, without firing a gun, was delivered up to the British admiral.

Notwithstanding the superiority of Great Britain by sea, the French, towards the close of this year, attempted an invasion of Ireland; but the plan was ill concerted, and, of course, unsuccessful. The whole conduct of it was intrusted to one man, General Hoche, and no second was prepared to occupy his place in case of any accident. The disaffected faction with whom the French meant to co-operate was not warned of their approach, and the fleet was sent towards a quarter of the country where the people were little disposed, or, at least, by no means prepared to receive them.

French Revolution, 1796.

287 Unsuccessful attempt by the French on Ireland.

Eighteen ships of the line, thirteen frigates, twelve sloops, and some transports, having 25,000 land forces on board, were employed in this expedition. When about to sail, it was detained for some time by a mutiny which arose in consequence of the enlistment of about 1,200 galley slaves. The fleet sailed on the 10th of December; but a ship of the line was lost in going out of Brest, and some of the rest were damaged. The frigate in which the commander in chief had embarked was separated from the fleet in a gale of wind; and the consequence was, that when the greater part of the fleet arrived at Bantry Bay, on the west coast of Ireland, nobody had instructions how to proceed. The troops and their officers wished to land, but the admiral, Bouvet, refused to comply with their request. Having remained several days upon the coast, he sailed for France, and arrived at Brest with a part of the fleet on the 31st of December. General Hoche did not reach Bantry Bay till it was too late, and therefore could not land. The fleet suffered great losses in its return. One ship of the line and two frigates foundered at sea, a frigate was taken by the British, and a ship of the line, after an engagement with two British ships, was run ashore to prevent her being captured.

1797.

At the commencement of the year 1797, the Archduke Charles was still occupied in the reduction of Kehl, and of the French fortifications opposite to Huningen. Moreau still commanded the army that opposed the Archduke; but General Hoche, after his return from the expedition to Ireland, was appointed to succeed Jourdan on the Lower Rhine. Bonaparte was still engaged in the blockade of Mantua, while the Austrian government was making vast efforts to recruit the army of Alvinzi after its defeat at Arcole, and to enable that General to make a last and desperate effort for the relief of Mantua. The young men of Vienna were urged to give their assistance on this important occasion, and 6000 of them marched into Italy as volunteers. Alvinzi's army amounted now to nearly 50,000 men; and he commenced his operations on the 8th of January, by skirmishing along the whole of the French line from below Porto Legnago upwards, to La Corona near the Lake Garda. He continued for some days to alarm the French at all points, and thus to conceal the plan of his future efforts. On the 10th Bonaparte was still at Bologna, on the other side of Mantua, taking precautions against the escape of Wurmser by that quarter, which, from an intercepted letter, he had learned was in contemplation. Being now informed of the approach of the Austrian army, he hastened to Mantua, and from thence to Verona, which was the centre of the line of his army that opposed Alvinzi. He arrived at Verona on the morning of the 12th; but as the Austrians continued to make their attacks upon all quarters at once, he was unable to penetrate the design of their leader. At last, on the 13th, the

288 Successes of the Austrians.

French Revolution, 1797. the efforts of the Auftrians began to affume a more formidable afpect on the lower part of his line near Porto Legnago; but on the evening of the fame day he received intelligence, that the upper extremity of his line, where Joubert commanded, had been attacked by fuch an immenfe fuperiority of numbers, that there could be no doubt that the greateft number of the Imperial troops was concentrated there. The poft of La Corona had even been forced, and Joubert compelled to withdraw to Rivoli, which he alfo abandoned.

298 They divide their army; The Auftrians ftill perfifted in their unfortunate plan of dividing their army, that they might have two chances of fuccefs. Ten thoufand chofen troops, among whom were the Vienna volunteers, were deftined under General Provera to penetrate to Mantua by Porto Legnago, at the lower extremity of the French line; while Alvinzi in perfon advanced with the mafs of the army againft Joubert at its other extremity. On the 13th all went well; Joubert was compelled to retreat; and he was fo fituated, that the eafy capture of his whole divifion on the following day appeared a very probable event.

Bonaparte, in the mean time, having learned the ftate of affairs, left Verona in the evening of the 13th, having firft ordered the whole centre of his army under Maffena to follow him to the neighbourhood of Rivoli with all poffible fpeed. Here he fpent the night with his officers in arranging the order of battle for next day, and in occupying proper pofitions. At day-break of the 14th the attack was begun by Joubert's divifion, to the no fmall furprife of the Imperialifts, who were not aware of the arrival of Bonaparte with reinforcements. The battle, however, was long and obftinate. The fuperiority of numbers on the fide of the Auftrians enabled them to defeat all the efforts of the French to turn their divifions. They at laft fucceeded in driving back upon the centre the two wings of the French army in confiderable diforder. Alvinzi now attacked the centre, which fcarcely maintained its pofition; and the Auftrian wings advancing on both fides, completely furrounded the French army. The victory feemed already won; and it is faid that Alvinzi difpatched a courier to Vienna to announce the approaching capture of Bonaparte and his army. Bonaparte indeed confidered his own fituation as very alarming; and is faid to have meditated his efcape acrofs the Auftrian right wing. From the nature of his order of battle, his troops had rather been concentrated than fcattered by the repulfe they had received, and it was therefore ftill in his power to make a defperate effort. Having formed three ftrong columns, he fent them againft the Auftrian right wing. They fucceeded in penetrating it at different points; and it fled in fuch confufion, that having encountered a party of French that had not arrived in time to join the body of the army, 4000 Auftrians laid down their arms in a panic, and furrendered themfelves prifoners of war. Night put an end to any farther conteft; but Bonaparte, confidering this quarter of his line as no longer in danger, departed to oppofe General Provera, leaving Joubert to profecute the victory now gained. This fervice he performed with great fuccefs. A detachment under General Murat having marched all the night of the 14th after the battle, feized Montebaldo in the rear of the pofition at Corona, to which a confiderable divifion of the Auftrians had retreated, while Joubert, next morning, attacked them in front. Finding themfelves furrounded, they foon fell into confufion. Six thoufand men were made prifoners, many were drowned in attempting to crofs the Adige, and the remainder fled to Tyrol. French Revolution, 1797. 290 And are defeated.

During this fanguinary conteft on the upper part of the Adige, General Provera had forced his paffage acrofs the lower part of that river at Angiara near Porto Legnago, and compelled the French General Guieux to retire to Ronco. Augereau collected all the troops in the neighbourhood, and marched to attack Provera; but as he haftened towards Mantua, Augereau could only come up with his rear; of which, after an engagement, he took 2000 prifoners. On the 15th, however, General Provera arrived in the vicinity of Mantua. The city, which ftands in a lake, was blockaded at the two points, by which it has accefs to the main-land called *St George* and *La Favorite*. Alvinzi was to have formed his junction with Provera at the poft of St George. Receiving no intelligence of him, General Provera fummoned the French commander here to furrender; and on his refufal, endeavoured to carry the pofition by affault. Having failed in this attempt, he turned his attention towards the poft of La Favorite, which he attacked on the morning of the 16th: while Wurmfer, who had perceived his arrival, advanced with the troops of the garrifon againft the fame point. But by this time Bonaparte had arrived with reinforcements. General Wurmfer was repulfed (B); and Provera being completely furrounded by the French, was under the neceffity of furrendering himfelf with his troops prifoners of war. The refult of all thefe battles at Rivoli and Mantua was the capture of 23,000 prifoners and 60 pieces of cannon; and thus four Imperial armies had perifhed in Italy in the attempt to preferve Mantua. The capture of this city, however, was now inevitable, in con-
fequence of famine. It furrendered by capitulation on the 2d of February. Bonoparte on this occafion endeavoured to acquire the reputation of humanity. To allow the French emigrants in the garrifon to efcape, he confented to an article in the capitulation that General Wurmfer fhould be allowed to felect and carry out of the garrifon 700 men, who were not to be examined 291 Mantua furrenders.

(B) Marfhal Wurmfer had before this time begun to fufpect that his plans were betrayed to the enemy. When he refolved to make his laft fally to co-operate with Alvinzi, he kept his plan to himfelf; and in the morning of that day on which the army was to march out, he gave to each of the generals commanding the divifions (which we think were feven) his orders in a fealed packet. The troops marched at the hour fixed on, in fo many divifions; and they were inftantly attacked at all points by the enemy. Upon this the old General faid to a Britifh officer of high rank, who was with him in the fortrefs, We are betrayed, make your efcape by any means that you can. This anecdote was communicated to us through a channel which leaves no doubt of its truth in our own minds; but not being authorifed to give the *names* of our informers, we thought it not right to infert it in the text. Its truth or falfehood may be eafily afcertained.

French Revolution, 1797. mined nor confidered as prifoners; and the General himfelf was allowed to depart unconditionally.

292 The Pope perfeveres in hoftilities; In the meanwhile, the Pope, who of all the European princes had the beft reafon for difliking the French caufe, uncautioufly perfevered in hoftility, in the hope that fome one of the Imperial armies might fucceed in driving Bonaparte from Italy. Having recovered from the panic which induced him to folicit an armiftice when the French firft entered Lombardy, he had avoided concluding a treaty of peace, and attempted to enter into a clofe alliance with the court of Vienna. He procured officers to be fent from thence to take the command of his troops, and flattered himfelf with the vain hope of being able to make an important diverfion in favour of the Imperial troops.

As the Emperor and the French were both preparing with all poffible fpeed to renew their bloody conteft on the frontiers of Germany, it was of importance to Bonaparte to leave all Italy in peace on his rear. On the 1ft of February he fent a divifion of his troops under General Victor, along with what was called the *Lombard Legion*, confifting of Italians, to enter the territory of the Pope; and upon the furrender of Mantua Bonaparte followed in perfon. The troops of his Holinefs made feeble refiftance. The new raifed Lombard legion was made to try its valour againft them on the river Senis on the 2d. After ftorming their entrenchments, it took their cannon and 1000 of themfelves pri-

293 But is conquered. foners. Urbino, Ancona, and Loretto, fucceffively fell an eafy prey to the French. From the chapel at Loretto the papal General Colli had carried moft of the treafure; but the French ftill found gold and filver articles worth 1,000,000 of livres, and the image of the virgin was conveyed as a curiofity to Paris. Bonaparte now proceeded through Macerata to Tolentino. He was here met by a meffenger from the Pope with offers of peace, and concluded a treaty with his Holinefs on the 19th. By this treaty the conditions of the armiftice were confirmed; and in addition to the payments then ftipulated, the Pope promifed to pay 15,000,000 of livres, and to deliver 800 cavalry horfes, with as many draught horfes and oxen. He alfo engaged to pay 300,000 livres to the family of the French envoy Baffeville, who had been murdered at Rome, and to apologife by his minifter at Paris for that event.

294 Bonaparte reinforced. The French had been fo unfuccefsful in their late irruption into Germany, through Swabia and Franconia, that they now refolved to make their principal effort from Italy under Bonaparte. For this purpofe, the Directory detached great bodies of the veteran troops that had fought under Moreau as fecretly as poffible through Savoy into Italy. The court of Vienna, however, was aware of the approaching danger, and gave the command on the fide of Italy to the Archduke Charles, who of all their military leaders had alone of late been fuccefsful againft the French. He brought along with him his beft troops from the Rhine, and numerous levies were endeavoured to be made in all the hereditary ftates for his farther fupport. The war was now about to be carried into new territories, on which the houfe of Auftria had fcarcely hitherto beheld a foe. It was neceffary that Bonaparte fhould once more attempt to fcale the fummit of the Alps. This immenfe chain of mountains, which takes its rife in the vicinity of Toulon, at firft ftretches northward under the names of *Piedmont* and *Savoy*. It then runs towards the eaft, forming the countries of Switzerland, Tyrol, Carinthia, and Carniola. The three laft of thefe, paffing along the head of the Adriatic, form the frontier in this quarter of the hereditary ftates of Auftria. Between the mountains and the fea lies the level and fertile tract of territory which belonged to Venice. It is croffed by many large ftreams, which are fed by the melting fnows of the Alps, and whofe nature is this, that they are greateft in fummer, and that their waters diminifh during the frofts of winter.

295 Blunder of the Court of Vienna. The council of war at Vienna now committed an important error in the plan of defence which it adopted. Inftead of making a ftand in the defiles of the mountains, the Archduke was fent down into the plain to defend the paffages of the rivers. War is effentially an offenfive art. Whatever the general purpofe of hoftility may be, it is always conducted with moft fuccefs when the detail of its operations is fo managed as to affume the form of enterprife and of vigorous attack. This arifes not from any thing in the nature of the art of war, but from the immutable conftitution of the human character. The ftrength of men who are fixed without motion in a particular fpot, is fubdued by the depreffing paffion of fear, and by the defpair of accomplifhing any important object; whereas, when urged to action and to enterprife, their energy is increafed by hope, and by that prefumption of their own fuperiority which all men readily entertain. Hence we have fo few inftances in hiftory of nations fuccefsfully defended by rivers or extenfive fortified lines; whereas mountainous countries have ufually fet bounds to the progrefs of armies. In fuch fituations, the defending party can always act upon the offenfive. He finds his adverfaries divided, by their fituation, into fmall parties. He hopes to vanquifh them in detail, and he acquires ftrength and courage from the profpect of fuccefs.

While Bonaparte was advancing into the territory of the Pope, the Auftrian army was arranging itfelf along the eaftern bank of the Piava. The French were on the oppofite bank, and Bonaparte haftened to join them after he had concluded his treaty with the Pope. The beginning of March was fpent in preparations; but at laft the troops advanced, that the point of refiftance might be difcovered. Having croffed the Piava on the 12th of March, the Auftrians retired, fkirmifhing for fome days till they had croffed the Tagliamento, where they made a ftand with their whole force. 296 Progrefs of the French army. Early on the 17th the French army arrived at Valvafone, on the oppofite bank; and after fome hefitation, refolved to force the paffage of the river. To have accomplifhed this object very fpeedily would have been difficult, had not a recent froft diminifhed the ftream, by which means the French were enabled to crofs it in the face of the enemy in columns at various points. The army of Bonaparte was now in three divifions. Joubert, with the left wing, advanced along the courfe of the Adige into Tyrol, and was ordered to crofs over from thence, and to defcend along the valley of the river Drave, which is beyond the higheft chain of what the Romans called the *Noric Alps*. Maffena, with the centre, after croffing the Tagliamento, advanced into the defiles of thefe mountains; while the right divifion, which was attended by Bonaparte in perfon, proceeded along the coaft of the Adriatic.

French Revolution, 1797.

After forcing the paſſage of the Tagliamento on the 17th, the French had eaſily defeated the Auſtrians on the oppoſite bank, and compelled them everywhere to retreat. The other rivers were eaſily paſſed; and on the 19th, the town of Gradiſca, on the river Liſonzo, ſurrendered to the right wing of the army, and its garriſon, amounting to 3000 men, were made priſoners of war. On the 21ſt Goritz was entered by the ſame diviſion, who found there the principal Auſtrian magazines and hoſpitals. Trieſte was entered on the 23d; and the French ſent off in waggons, from the quickſilver mines of Ydria, materials worth 2,000,000 of livres. In the mean time, the Auſtrians, in their haſty retreat, entangled themſelves and their baggage among the mountains. On the 24th, a large body of them was hemmed in between Maſſena, who had reached Tarvis, and a part of the French right wing under Guieux. Reinforcements, however, having found means

297 The Auſtrians defeated.

to reach them from the Archduke's head quarters at Clagenfurt, they hazarded an engagement on the following day, but were defeated, with the loſs of 5000 taken priſoners, and 400 waggons loaded with baggage. The French left wing under Joubert, Baraguay D'Hilliers, and Delmas, was equally ſuccesſful. On the banks of the Lavis, after an obſtinate engagement, 4000 Auſtrians were taken; and thereafter at Clauzen they were again defeated, with the loſs of 1500 taken priſoners. Having entered Brixen, this diviſion turned eaſtward, and deſcended the valley of the Drave towards Clagenfurt, the capital of Carinthia, where it was met by General Maſſena; the Archduke, after a ſlight conteſt, having evacuated the place, and advanced farther towards the capital of the empire, which was now ſeriouſly menaced, and in which great conſternation

298 Wonderful ſucceſs of Bonaparte.

prevailed. In 15 days Bonaparte had taken 20,000 priſoners, and croſſed the Alps; and though the country ſtill preſented ſome difficulties, there was no fortified place capable of reſiſting his progreſs towards Vienna. He did not, however, conſider his own ſituation as deſtitute of hazard, and ſeized the preſent moment of unbounded ſucceſs to make propoſals of peace. On the 31ſt of March he ſent a letter to the Archduke, in which he depricated the uſeleſs prolongation of the war, and intreated him to interpoſe his good offices to put a ſtop to its farther ravages. But this prince, who ſeems to have doubted his own influence at the court of Vienna, returned a cold anſwer, ſtating, that it belonged not to him to inveſtigate the principles on which the war was carried on, and that he had no powers to negociate.

299 Partial ſucceſſes of the Auſtrians.

The Auſtrian chiefs made a laſt effort, by raiſing the peaſants of the Tyrol in a maſs to embarraſs the rear of the French. They accordingly gained ſome ſucceſſes under General Laudohn, and drove out the French troops that had been left at Botzen and Brixen. The inhabitants of the Venetian ſtates alſo roſe againſt the troops that remained in their country; and being joined by ten regiments of Sclavonians, which had been in the pay of the government of Venice, they put the French to death wherever they were found, without excepting the ſick in the hoſpitals, of whom 500 were maſſacred at Verona. A party of Imperialiſts alſo drove the French garriſon out of Trieſte, and thus attempted to ſurround the invading army. Bonaparte, however, knew that the court of Vienna muſt be at leaſt as much embarraſſed as himſelf. His army amounted to 95,000 men. It had hitherto proved irreſiſtible; and the Auſtrians knew, that to ſurround was not to conquer it. He therefore perſiſted in advancing. On the 2d of April he ſucceeded in forcing the ſtrong defiles between Freiſach and Newmark, after a bloody battle, in which he took 600 priſoners. On the 4th, his advanced guard reached Hunſmark, where the Auſtrians were again defeated; and his army occupied Kintenfeld, Murau, and Judenbourg. Theſe advantages compelled the Auſtrian cabinet to treat for peace, as there was no longer any point at which the Archduke's army could hope to make a ſtand till it came to the mountains in the vicinity of Vienna. Meaſures were taken for removing the public treaſure and effects into Hungary, while Generals Bellegarde and Morveld were ſent to requeſt from Bonaparte a ſuſpenſion of hoſtilities. On being ſuffered to take poſſeſſion of Gratz and Leoben, within little more than 50 miles of Vienna, he conſented, on the 7th of April, to an armiſtice, which was only to endure till the night of the 13th, but was afterwards renewed for a longer period. It was followed on the 19th by a preliminary treaty, ſigned at Leoben; by which it was agreed that the Auſtrian Netherlands ſhould belong to France, and that the new republic in Lombardy ſhould continue under the name of the *Ciſalpine Republic*, and ſhould include the Milaneſe, the duchy of Mantua, and the territories of Modena, Ferrar, and Bologna. There is reaſon to ſuſpect that ſomething hoſtile to the independence of Venice was here alſo ſtipulated.

300 The Auſtrian cabinet treats for peace.

301 Unjuſt and cruel conduct of Bonaparte.

Bonaparte agreed to withdraw without delay into Italy, on receiving ſubſiſtence for his army during its march; and it was reſolved, that all farther diſputes ſhould be afterwards ſettled by a definitive treaty of peace. On his return he accuſed the Venetian government of connivance at the inſurrection which had taken place againſt the French in his abſence; and having ſeized their city and whole territory, he diſſolved that ancient and ſingular, but now feeble, ariſtocracy.

While Bonaparte was advancing towards Vienna, the French armies on the Rhine had begun to preſs upon the Auſtrians, to prevent farther reinforcements from being ſent againſt him from that quarter. The Auſtrians offered an armiſtice; but as the French demanded the fortreſs of Ehrenbreitſtein as the price of it, both parties prepared for action. The left wing of the army of General Hoche advanced rapidly from Duſſeldorf, while the centre and right wing croſſed the Rhine near Coblentz. The Auſtrians under General Wernecht retreated to the Lahn, where they waited the arrival of the French. Here a violent conteſt enſued on the 18th of April, in which 4000 Auſtrians were taken priſoners. The French took poſſeſſion of Wetzlaer, and drove their antagoniſts to the gates of Francfort. In the mean time, General Moreau, on the Upper Rhine, forced the paſſage of the river near Straſburg, and attacked the village of Dierſheim, of which he at laſt retained poſſeſſion, after having been more than once driven out, and the village nearly deſtroyed. The following day, however, the Auſtrians renewed the attack, and forced the French for ſome time to give way; but powerful reinforcements having croſſed the river,

302 Succeſſes of the French on the Rhine.

French Revolution, 1797.

river, the French were at laſt enabled to renew the battle with ſuch vigour, that they took Fort Kehl, together with 5000 priſoners. The Imperialiſts in this quarter were now purſued towards the Danube; when all military operations were ſuddenly arreſted by meſſengers ſent through Germany by the Archduke Charles and Bonaparte, announcing that peace was concluded. These meſſengers found the army of Hoche violently attacking Francfort on the Maine, which General Wernecht was endeavouring to defend. The news was diffuſed in an inſtant through both armies; and the contending troops, throwing aſide their weapons, congratulated each other upon the event.

303 Peace concluded.

304 Power of France at this period.

France now held a very elevated rank, and a formidable character, among the nations of Europe. Spain, Italy, and Holland, were held in dependence; while her victorious armies had compelled the laſt continental member of the coalition to accept of peace from an army that approached his capital. Had the Auſtrian officers been faithful, and the court of Vienna leſs ſelfiſh, ſubſequent events have indeed ſhewn that the affairs of the Emperor were not yet deſparate, and that Bonaparte was not that invincible hero which his rapid ſucceſſes gave ſome reaſon to ſuppoſe him. After the peruſal of his letters from Egypt, his victories loſe much of their brilliancy; nor does any action, or all the actions of his life, diſplay ſuch military ſkill, as the retreat of Moreau through Swabia, when preſſed on the rear by a victorious army, and ſurrounded on all hands by an incenſed populace. But Bonaparte had been ſucceſsful; the Archduke knew not whom to truſt: there is reaſon to believe that his plans were continually thwarted by a corrupt council at home; and the court of Vienna was bribed to make a peace. Of all the enemies of the French revolution, Britain alone remained in hoſtility. From her command of the ocean, ſhe was enabled indeed to retain the feeble ſtate of Portugal, attached to her cauſe; but on land, ſuch was the terrible energy of France, that, with this exception, which ſeemed only to exiſt by tolerance, the Britiſh trading veſſels were excluded, by her influence, from all approach to the continent, from the Elbe to the Adriatic; and the Britiſh government was once more induced, in theſe circumſtances, to try the effect of a new negociation. All theſe external advantages, however, were ſpeedily loſt by the French nation; and it ſeemed the unhappy deſtiny of this people to be conſtantly deprived of the fruits of all their ſufferings, and their courage, by the turbulence of their domeſtic factions, and the profligacy and unprincipled conduct of their rulers.

305 Britain continues the war.

306 Conteſt between the Directory and Councils.

A ſerious conteſt between the executive power and the legiſlature was now approaching. We already remarked, that the Directory was originally ſelected by thoſe men who had been the aſſociates of Robeſpierre; and though deſerted of late by ſome of the more violent ſpirits, who were termed *Anarchiſts*, it was ſtill conſidered as the head of the Mountain party. By the victory obtained over the ſections of Paris on the 5th of October, all oppoſition had been ſet at defiance for a time; but the nation at large had never been reconciled to theſe men. The period now arrived when a third of the legiſlative body was to be changed. On the 19th of May, Letourneur went out of the Directory by lot. On the 20th, the new third took their ſeats in the Councils, a third of their predeceſſors having evacuated their ſeats by lot; and on the following day, Barthelemi, the ambaſſador to Switzerland, was choſen to ſucceed Letourneur in the Directory. The election of the members of the new third had almoſt entirely fallen upon men who were underſtood to be hoſtile to the Directory. Many Generals out of employment were choſen; ſuch as Pichegru, Jourdan, and Willot, and many repreſentatives of the families of the ancient nobility who had not emigrated (among whom was the Prince of Conti) were now elected into the legiſlature. The moderate or oppoſition party in the two Councils now poſſeſſed a complete majority. Carnot and Barthelemi were underſtood to be favourable to them in the Directory; the former having made his peace with them, and the latter being eſtabliſhed by themſelves. The effect of this change in the ſtate of the Councils ſpeedily appeared in their adopting every meaſure that could embarraſs the Directory, or caſt odium upon the Mountain party, and alter the ſtate of things which it had eſtabliſhed.

On the 14th of June, Gilbert Deſmolieres brought forward a report from a committee upon the ſtate of the finances; in which he exhibited and reprobated in the ſtrongeſt terms the prodigality of the Directory, and the profuſion and rapacity of its agents. On the 18th the ſame committee propoſed a new plan of finance, the object of which was to deprive the Directory of any ſhare in the adminiſtration of the public money. In the mean time, on the 17th of the ſame month, Camille Jourdan had preſented a long report on the ſubject of religion; in which he endeavoured to demonſtrate the impropriety of prohibiting the public diſplay of its ceremonies, and the injuſtice of the perſecution which its miniſters had undergone for refuſing to take oaths preſcribed by the legiſlature. This report was afterwards, on the 15th of July, followed up in the Council of Five Hundred, by a decree, repealing all the laws againſt refractory prieſts, or which aſſimilated them to emigrants. On the following day, another decree, requiring from them a declaration of fidelity to the conſtitution, could only be carried by a majority of 210 againſt 204. A propoſal was now brought forward in the Council of Five Hundred by Emery, a new member, to repeal the laws which confiſcated the property of emigrants, and to allow their relations to ſucceed to them as if they had died at the period of their emigration. Thoſe who had fled into foreign countries from Toulon and other places, during the reign of terror, were alſo encouraged to return, and allowed to expect that their names would be erazed from the liſt of emigrants. The conduct of the Directory towards foreign powers was attacked on different occaſions; and Dumoullard propoſed the appointment of a committee to enquire into the external relations of the republic. This was a delicate ſubject; as it involved the character of the armies and their leaders, and as it might ſubvert the intereſts of the Directory with ſome of their friends of the Mountain party. The Venetian republic, though a neutral ſtate, had been overturned by Bonaparte on account of a popular inſurrection, for which the government apologiſed. Little account had been given of the immenſe ſums of money that had been levied in Italy. The armies in the preceding year had entered Germany in the character of plunderers;

307 Mild meaſures of the Councils.

plunderers; which had diſguſted all thoſe in that country who had once been friendly to their cauſe, and longed for their arrival. The Directory, at the ſame time, inſtead of encouraging the progreſs of revolution, which the Jacobins eagerly deſired, had ſuddenly made peace with the German princes, upon receiving pecuniary contributions, which were left to be exacted according to the ancient laws of the different ſtates (which exempt the nobles and the clergy) and thus fell heavieſt upon thoſe very perſons who had cheriſhed the new republican principles.

The diſcuſſion of theſe ſubjects brought the majority of the Directory and of the Councils into a ſtate of complete hoſtility. Both parties reſolved to violate the conſtitution, under the pretence of preſerving it. The one wiſhed to change the Directory before the time preſcribed by law, and the other to deprive of their ſeats a great number of the new legiſlators elected by the people. Barras was the moſt obnoxious of the directors; and an attempt was made to deprive him of his office, upon the footing that he was leſs than 40 years of age. But his colleagues aſſerted that he was born in the year 1755; and as no proof to the contrary could be brought, this abortive attempt ſerved only ſtill farther to irritate the contending parties, and they began to prepare for more effectual meaſures. Had not force been ſpeedily uſed on the ſide of the Directory, the Councils muſt naturally have prevailed.

308 Their popularity.

The majority of the people confided in them. The national purſe was in their hands; and they hoped to ſubdue the Directory, as the conſtituent aſſembly had done the king, by avoiding to vote the neceſſary ſupplies. They could enact what laws they pleaſed. They had not indeed the command of the armies; but to remedy their weakneſs in this reſpect, General Pichegru, on the 20th of July, preſented a plan for reorganiſing the national guard, and placing it more at the diſpoſal of the Councils, by depriving the Directory of the nomination of the officers.

In the mean time the Directory was by no means deſtitute of adherents. The reſolutions of the Councils in favour of the prieſts, and the relations of emigrants, looked ſo like a deſertion of former maxims, that many perſons expected an immediate counter revolution. The royaliſts gained courage, and a multitude of journals or newſpapers, favourable to their cauſe, began to be publiſhed. Emigrants obtained paſſports, and haſtened to Paris in the hope of being ſtruck off the liſt, upon alledging that they fled to avoid proſcription during the power of the Jacobins. The effect of all this was, that the purchaſers of national property, and thoſe who had become rich by the revolution, were alarmed. The whole Mountain party, and all thoſe who had been active in oppoſition to royalty, rallied round the Directory. The armies, whoſe chiefs found themſelves involved in ſome of the accuſations brought againſt that body, ſent addreſſes, in which they declared their reſolution to ſupport its power. The Councils declared theſe addreſſes, which the Directory had received from armed bodies, unconſtitutional, and procured counter-addreſſes from different departments. At laſt the partizans of the two contending powers began to diſtinguiſh themſelves in Paris by their dreſs, and every thing preſaged an approaching appeal to force. On the 20th of July the Councils received intelligence that a diviſion of the army of General Hoche had advanced within a few leagues of Paris; whereas, by the conſtitution, the Directory incurred the penalty of ten years impriſonment if it authoriſed troops to approach nearer to the reſidence of the legiſlative body than twelve leagues, without its own conſent. An explanation of this event was immediately demanded. The Directory denied that they had ordered the march, and aſcribed it to a miſtake of the officer by whom it was conducted. Their explanation was treated with contempt, and much angry debate took place in the Councils concerning it; the Directory all the while conducting themſelves with much ſeeming moderation, and even ſubmiſſiveneſs. In the mean time their antagoniſts acted a very undecided part.

309 The Directory victorious.

They long hoped to gain Lareveillere Lepaux to their ſide; in which caſe they would have had a majority in the Directory. This vain expectation rendered their conduct indeciſive. At length the majority of the Directory procured an addreſs of adherence from the ſuburb St Antoine, which in all the tempeſtuous days of the revolution had been the rallying point of the Mountain party. Encouraged by this addreſs, they proceeded to immediate action. General Augereau had been ſent from Italy under pretence of preſenting ſome Auſtrian ſtandards to the Directory, and he was employed as their tool upon this occaſion. They commanded the garriſon of Paris, and they had managed to bring over to their party the ſoldiers compoſing the guard of the two councils. Before day-break, on the morning of the 4th, Augereau ſurrounded the Thuilleries with a diviſion of the troops. The guard of the Councils refuſed to reſiſt, and their commander, Ramel, was taken priſoner. Having entered the hall, he found Pichegru and other twelve of the chiefs of the oppoſite party ſitting in conſultation, and immediately ſent them priſoners to the Temple. Some other obnoxious members of the Councils were alſo put under arreſt. The director Carnot had made his eſcape on the preceding evening, but Barthelemi remained, and was impriſoned.

All this was accompliſhed without noiſe, and in an inſtant. Many members of the Councils, when they came to the hall at the uſual hour were ſurpriſed to find that ſeals were put upon the doors, and that they could not obtain admittance. They were invited, however, to go to the Surgeons Hall and the theatre of the Odeon, where they were told the Directory had appointed the Councils to aſſemble. At theſe places, about forty of the Council of Ancients, and double that number of the other Council, aſſembled about noon, and ſent to demand from the Directory an account of the proceedings of the morning. They received an anſwer, declaring, that what had been done was neceſſary to the ſalvation of the Republic, and congratulating the Councils *on their eſcape* from the machinations of royaliſts.

310 Pretended conſpiracy.

Being ſtill at a loſs how to act, the Council of Five Hundred appointed a committee of four members (of whom Sieyes was one) to report upon the meaſures to be adopted. On the following day Boullay de la Meurth preſented a report from this committee, in which he announced, that a vaſt royaliſt conſpiracy, whoſe centre was in the boſom of the Councils, had been formed to overturn the conſtitution, but that it had been baffled by the wiſdom and activity of the Directory. The report concluded, by propoſing the immediate tranſportation of the conſpirators without a trial.

trial. Accordingly, theſe degraded repreſentative bodies proceeded, after ſome debate, on hearing the names of the accuſed perſons read over, to vote the tranſportation to Guiana in South America, of fifty-three of their own members, and twelve other perſons, among whom were the directors Carnot and Barthelemi. They annulled the elections in forty-nine departments, repealed the laws lately enacted in favour of the diſaffected clergy and the relations of emigrants; and even ſo far aboliſhed the liberty of the preſs, as to put all periodical publications under the inſpection of the police for one year. New taxes were voted without heſitation, Francis de Neufchauteau and Merlin were elected to fill the vacancies in the Directory, and affairs were endeavoured to be conducted in their ordinary train.

All this while the city of Paris remained tranquil. That turbulent capital, which had made ſo many ſanguinary efforts in favour of what it accounted the cauſe of freedom, had been ſo completely ſubdued ſince its unfortunate ſtruggle on the 5th of October, that it now permitted the national repreſentation to be violated, and the moſt obvious rules of practical

311 Employed by the Directory to juſtify their conduct.

liberty to be infringed, without an effort in their defence. The Directory, in the mean time, attempted to juſtify their conduct to the nation at large, by publiſhing various documents intended to prove the exiſtence of a royaliſt conſpiracy. The moſt remarkable of theſe was a paper, ſaid to be written by M d'Antraigues, and found by Bonaparte at Venice; in which a detail was given of a correſpondence between General Pichegru and the Prince of Condé in the year 1795. The correſpondence itſelf was alſo, at the ſame time, ſaid to be found by General Moreau among papers taken by him at the late paſſage of the Rhine. It ſtated, that Pichegru had offered to the Prince of Condé to croſs the Rhine with his army, and having joined the Auſtrians under General Wurmſer, and the emigrants under the Prince of Condé, to return with the united armies and march to Paris, where they were to re-eſtabliſh royalty. The Prince is ſaid to have refuſed to accept of the offer, from jealouſy of the participation of the Auſtrians in the honour of the tranſaction. He therefore inſiſted that it ſhould be conducted without their aid; but Pichegru thought the attempt too hazardous in this form, and, being ſoon after removed from his command, the project failed. At the time of its publication, the genuineneſs of this correſpondence, and alſo of the paper found by Bonaparte, was denied; and nothing has appeared ſince to induce an unprejudiced man to think otherwiſe at preſent. Moreau, who was certainly involved in this conſpiracy, if real, has been intruſted ſince that period with the command of the armies of the republic; and though defeated by Marſhal Suwarrow, he is ſo far from being now conſidered as a royaliſt, that the revolutionary government ſeems inclined to intruſt to his military ſkill and fidelity its laſt efforts for the continuance of its exiſtence.

From the violation of the repreſentative government that has been now ſtated, it became obvious to ſurrounding nations, that France had paſſed under the dominion of a ſmall faction at variance with the majority

312 The Directory all powerful.

of the people. The Directory was all powerful. Its members, however, ſeem very ſoon to have become giddy by the elevated nature of their ſituation, and to have adopted a notion that there was no project of ambition or rapacity in which they might not venture to engage. During their conteſt with the Councils, they had protracted the negociations with Lord Malmeſbury at Liſle, and had ſuffered thoſe to relax which had been entered into between Bonaparte and the Imperial ambaſſadors at Campo Formio near Udine. Great Britain had offered to conſent to peace, on condition of being allowed to retain the Dutch ſettlement of the Cape of Good Hope, and the Spaniſh iſland of Trinidad, which had been taken in the month of February this year. The Directory now recalled their former negociators Letourneur and Maret, and ſent two others, Treilhard and Bonnier, in their ſtead; who immediately demanded whether Lord Malmeſbury had full power to reſtore all the ſettlements taken from France and her allies during the war? Upon his Lordſhip's declining to anſwer ſuch a queſtion, becauſe it implied an enquiry, not into his powers, which were in the uſual form, but into his inſtructions, which would preclude all negociation, he was required to return home to procure more ample powers. The negociations with the Emperor, however, were now ſpeedily brought to a concluſion. On the 17th of October, a definitive treaty was ſigned at Campo Formio. By it the Emperor gave up the Netherlands to France, the Milaneſe to the Ciſalpine republic, and his territories in the Briſgaw to the Duke of Modena, as an indemnification for the loſs of his duchy in Italy. The Emperor alſo conſented that the French ſhould poſſeſs the Venetian iſlands in the Levant of Corfu, Zante, Cephalonia, Santa Maura, Cerigo, and others. On the other hand, the French Republic conſented that the Emperor ſhould poſſeſs in full ſovereignty the city of Venice, and its whole other territory, from the extremity of Dalmatia round the Adriatic as far as the Adige and the lake Garda. The Ciſalpine Republic was to poſſeſs the remaining territory of Venice in this quarter, along with the city and duchy of Mantua, and the eccleſiaſtical ſtates of Ferrara and Bologna.

313 Treaty of Campo Formio.

Upon whatever principles the war might have hitherto been conducted, the terms of this treaty ſufficiently demonſtrated to all Europe, that its leſſer ſtates had no better reaſon to expect ſecurity from the houſe of Auſtria than from that of the new republic. This truth would have been ſtill more evident, had the articles of a convention, which was ſigned by theſe parties at the ſame period at Campo Formio, been publiſhed to the world. Fearing, however, to alarm too much the Germanic body, theſe articles were kept ſecret, and the parties agreed to prevail with the German princes, at a congreſs to be opened at Raſtadt, to conſent, in conſequence of an apparently fair negociation, to what France and Auſtria had determined ſhould take place. By the ſecret convention or treaty now alluded to, it was ſtipulated, that the Rhine, including the fortreſs of Mentz, ſhould be the boundary of the French Republic; that the princes, whoſe territories were alienated by this agreement, ſhould be indemnified by the ſecularization of church lands in Germany; that the Stadtholder of Holland ſhould be indemnified for the loſs of his eſtates in that country, by receiving German territory; that the Emperor ſhould receive the Archbiſhopric of Saltzburg, and the part of the circle of Bavaria ſituated between that archbiſhopric, the rivers Inn and Saltz, and the Tyrol; that the Imperial troops ſhould immediately withdraw to the confines of the hereditary ſtates beyond

French Revolution, 1797. yond Ulm; and if the Germanic body ſhould refuſe peace on the above terms, it was ſtipulated, that the Emperor ſhould ſupply to it no more troops than his contingent as a co-eſtate amounted to, and that even theſe ſhould not be employed in any fortified place.

Theſe treaties were immediately begun to be put in execution. The Auſtrians left the Rhine, which enabled the French to ſurround the fortreſſes of Mentz and Ehrenbreitſtein. Of the former, they ſpeedily obtained poſſeſſion; but the latter coſt them a very tedious blockade, before the garriſon, conſiſting of troops of the Palatinate, would agree to ſurrender. The Imperial troops, at the ſame time, entered Venice; the French having evacuated that city after carrying off or deſtroying its whole navy. The Ciſalpine Republic was eſtabliſhed, and Bonaparte left Italy; leaving, however, an army of 25,000 men to garriſon Mantua, Breſcia, Milan, and other places, and to retain this new

313 Violent meaſures of the Directory. republic in dependence upon France. Genoa was, at the ſame time, brought under a ſimilar dependence by means of popular commotion, inſtigated by the French, and a revolution in its government which took place at this period. And thus the French Directory, without the excuſe of hoſtility, as in the caſes of Holland and Spain, began a ſyſtem of interference in the affairs of weaker neighbouring ſtates, which was ſpeedily carried to an height that once more alarmed all Europe. Theſe men even attempted, at this time, to compel the ſtates of North America to purchaſe with money their forbearance from war. This was done through a circuitous channel, and in the form of an intrigue, by private perſons, who were inſtructed to inform the American miniſters at Paris, that a large loan on the part of America would be the beſt means of ſecuring peace; and it was hinted, that it would be rendered more acceptable if accompanied with a private preſent of L. 50,000 ſterling to the members of the Directory. This laſt propoſal was indeed denied by the French miniſter Tallyrand, who had given his countenance to this crooked negociation: but the general impreſſion produced by the tranſactions could not be removed; and its effect was to injure very deeply the character of the French government in the opinion of thoſe diſtant nations that were otherwiſe diſpoſed to regard it in the moſt favourable light. Nor was its reſpectability increaſed by a law which the two Councils, at the deſire of the Directory, thought fit to enact, declaring the ſhips of all neutral ſtates bound for Britain, or returning from thence, liable to capture. This law was not leſs impolitic than unjuſt. It placed the whole carrying trade of the weſtern world in the hands of the Britiſh, and thus enriched the very people whom it was intended to injure.

For at this period Britain had acquired over the

314 Invaſion of Wales. ocean a degree of uncontrouled dominion that was altogether unexampled in former times. During the whole year the French fleet lay blockaded in its owns ports, and no enterpriſe was attempted by ſea, excepting in one ſolitary but ſingular inſtance. We have already mentioned that a number of galley ſlaves were ſent as ſoldiers with Hoche in his attempt upon Ireland. On the failure of that expedition, the Directory were at a loſs how to diſpoſe of theſe men. They could not now with propriety be ſent back to puniſhment, the troops would not ſerve along with them in the army; and as the new laws of France allow no remiſſion of crimes, they could not receive a pardon, nor was it ſafe to let looſe upon the country 1400 criminals. In this dilemma, the Directory reſolved to throw them into England. Accordingly, they were ſent in two frigates and ſome ſmall veſſels to the coaſt of Wales, and there landed with muſkets and ammunition, but without artillery. In the evening of the very day on which they landed, the 23d of February, they ſurrendered themſelves priſoners of war to a party of militia, yeomanry, cavalry, colliers, and others, under the command of Lord Cawdor. The Directory boaſted that, by this enterpriſe, they had demonſtrated the poſſibility of landing troops on the Britiſh coaſt in ſpite of the vigilance of the navy; but this aſſertion was ill ſupported by the fate of the two frigates accompanying the expedition; both were captured in attempted to return to Breſt.

Though the French navy remained in port, and conſequently ſafe during the reſt of the year, their allies, the Spaniards and Dutch, ſuffered ſeverely. On the 14th of February, a Britiſh fleet of 15 ſail of the line, under the command of Sir John Jervis, engaged the Spaniſh fleet, amounting to 27 ſail of the line, off Cape St Vincent. In this action, the Spaniſh force, if it be eſtimated by the number of men, the number of guns, and the weight of metal, was more than double that of the Britiſh; but by the ſkilful manœuvres of its heroic commander, the Britiſh fleet twice croſſed through the line of the Spaniards, and ſucceeded in cutting off a part of their fleet from the reſt. Four ſhips of the line were taken, and the Spaniſh admiral's own ſhip eſcaped with difficulty. The fleet had been on its way to Breſt to join the French fleet there; but in conſequence of this action, it returned to Cadiz, where it was blockaded by the Britiſh. 315 Brilliant victory of Sir John Jervis over the Spaniſh fleet,

For his gallant conduct in this engagement, which, when every circumſtance is taken into conſideration, is perhaps unparalleled in the annals of naval war, Sir John Jervis was immediately created Earl St Vincent, and received the thanks of both houſes of the Britiſh Parliament.

The Dutch were ſtill more unfortunate. The Texel, within which their fleet lay, was blockaded during the whole ſummer by Admiral Duncan. The French intended, by means of the Dutch fleet, to make another attempt upon Ireland. Troops were accordingly embarked, under the command of General Daendels; but a reſolution having at laſt been adopted of hazarding an engagement with the Britiſh, the Dutch admiral De Winter, in oppoſition to his own remonſtrances, was ordered to put to ſea. The Britiſh admiral had by this time left his ſtation near the Texel, and gone to Yarmouth to refit. On receiving intelligence, however, that the Dutch had ſailed, he inſtantly proceeded in queſt of them. On the 11th of October the Britiſh fleet, amounting to 16 ſail of the line and 3 frigates, came in ſight of the Dutch fleet, which in force was nearly equal, within about nine miles of Camperdown in Holland. Admiral Duncan immediately run his fleet through the Dutch line, and, though on a lee ſhore, began the engagement between them and their own coaſt. A moſt bloody and obſtinate conflict enſued, which laſted nearly three hours. By that time, it is ſaid that almoſt the whole Dutch fleet had ſtruck. The ſhips could not all be approached and ſeized, however, 316 And of Admiral Duncan over the Dutch.

French Revolution, 1798. ever, on account of the shallowness of the water upon the coast, to which the fleets were now very near. Eight ships of the line, with two of 56 guns, and one of 44, were taken, besides a frigate, which was afterwards lost near the British coast, and one of the ships of 56 guns foundered at sea. Admiral de Winter was taken with his ship, and also the Vice-admiral Rentjies.

Similar honours were conferred upon Admiral Duncan as upon Sir John Jervis, and both admirals had each a pension of L.2000 *per annum* conferred upon him for life, with the full approbation, we may venture to say, of every well affected man in the kingdom.

1798. The internal history of France now ceased to be very interesting. Political freedom could not be said to
317 Decline of public spirit in France. exist after so many of the representatives chosen by the people had been driven from the legislature, and the departments reduced to the necessity of electing men more acceptable to their present rulers. Public spirit therefore rapidly declined. The high notions of the freedom and felicity it was about to enjoy, which had once been so eagerly cherished by a great part of the nation, now gave way to a growing indifference about political questions, and the future destiny of the republic; for the people at large found themselves little interested in a government which existed independent of their will, which consisted of a narrow circle of persons, and whose conduct was surely not less crooked, intriguing, and unprincipled, than that of the ancient royalty, and its attending court, from which they had escaped; whilst its ferocious cruelty, and total disregard even of the forms of justice, were infinitely greater. But though the Directory was all-powerful, yet its power was limited by the present state of things, which denied it the possession of an abundant revenue. It had not yet been found possible to re-establish a system of productive taxation. The legislative councils, indeed, who now complied with every wish of the Directory, voted abundance of taxes; but these were scantily paid; partly on account of the total loss of the national commerce, and partly because the people were not disposed to make great exertions in this way for the support of government. By the constitution, they still possessed the election of the judges and other magistrates; the country was filled with veteran soldiers, who at different
318 Measure of the Directory. times had returned from the armies after the lapse of the usual period of service. The Directory, kept in awe by these circumstances, turned its attention abroad, and found means to establish an extensive patronage, by dividing among its adherents the plunder of neighbouring states, in whose welfare the people of France were little interested. The Girondist party had formerly proposed to propagate their principles by establishing a number of petty republics in the vicinity of France. The Directory now adopted the same project; that, under the pretence of diffusing liberty, they might obtain new sources of revenue and of power, by the dominion which they meant to exercise over these new governments. Holland and the Cisalpine republic were already placed in dependence upon them; and Rome and Switzerland readily afforded them opportunities for extending their plan.

319 Embassy to Rome. After the treaty with the Emperor had been concluded at Campo Formio, Joseph Bonaparte, brother of the General, had entered Rome as ambassador from the French Republic. The Pope, now deprived of all hope of foreign aid, and accustomed to humiliations, had submitted to every demand made by him for reducing the number of his troops, and setting at liberty persons imprisoned on account of political opinions. But an event soon occurred to afford the Directory a pretence for accomplishing the ruin of this decayed government. On the 26th of December 1797, three persons had waited upon the French ambassador, and solicited the protection of his government to a revolution which a party at Rome meant to accomplish. He rejected their proposals, and dissuaded them from the attempt; but did not, as was certainly his duty, communicate these proposals to the papal government, to which he was sent on a friendly embassy. On the following day, however, a tumult took place, in which the French cockade was worn by about 100 insurgents. They were speedily dispersed, but two of the Pope's dragoons were killed. The ambassador, who probably knew the disposition of the Directory towards the Pope, seems to have resolved that his own personal conduct should be blameless on the occasion. He therefore went on the 28th of December to the secretary of state, and presented a list of the persons under his protection who were entitled to wear the French cockade, consenting that all others adopting it should be punished. He also agreed to surrender six of the insurgents who had taken refuge in his palace. Towards the evening of this day, however, the popular tumult became more serious, particularly in the courts and neighbourhood of the French minister's palace. The Pope appears to have been personally unacquainted with the state of affairs; but the governor of the city sent parties of cavalry and infantry to disperse the insurgents. About twenty persons, having a Frenchman at their head, had, in the mean time, rushed into the palace, and demanded aid towards accomplishing a revolution. A number of French officers, and others who were with the ambassador, proposed to drive the whole insurgents by force from the jurisdiction of the palace. This was certainly a salutary advice, and such as could not have been rejected by the ambassador, had not his designs been hostile to the established government. Rejected, however, it was; for, pretending to believe that his authority would be sufficient to accomplish the object in a peaceable manner, he went out into the court to address the multitude. He was prevented from doing so by a discharge of musquetry from the military, who were firing within the jurisdiction of the palace. He interposed with his friends between the military and the insurgents; and while a part of the French officers in his train drove back the insurgents with their sabres, the ambassador advanced towards the soldiers, and demanded why they presumed to violate his jurisdiction? as if the jurisdiction of a foreign ambassador were a legal asylum for men in open rebellion against the government of the state. It is not, therefore, surprising, that no attention was paid to this arrogant and absurd demand; and the nature of the ground being such, that the troops could fire over his head upon the multitude in the rear, they made a second discharge, which killed several of the insurgents. Upon this the ambassador advanced close upon the soldiers, to prevail with them to depart; but they remained in a menacing attitude, and prepared for another discharge. Eager to prevent this, the French General Duphot, who was with the ambas-

French Revolution, 1798. 320 Insurrection in that city.

French Revolution, 1798.

ambaſſador, and was next day to have married his ſiſter, ruſhed into the ranks of the military, intreating them to deſiſt. Here a petty officer of the Pope's troops
321 A French general killed. diſcharged his muſket into the body of Duphot. Upon this, the ambaſſador and his other friends found it neceſſary to make their eſcape through a bye-way into the palace. The Spaniſh miniſter hearing of this event, ſent to the ſecretary of ſtate to proteſt againſt this violation of the privileges of ambaſſadors But the government, equally alarmed and perplexed by the fear of a revolution, and of French vengeance, remained during many hours totally inactive. All this while the palace of the French ambaſſador remained cloſely beſet by the military, who occupied the whole of its juriſdiction, and all its courts and paſſages. He at laſt ſent to demand paſſports, to enable him to leave the territories of the Pope. They were granted; but with many proteſtations of the innocence of the government, and its regret on account of this unfortunate occurrence.

Joſeph Bonaparte retired to Florence, and from thence to Paris. The Pope ſolicited the protection of the courts of Vienna, Naples, Tuſcany, and Spain; but they all ſtood aloof from his misfortunes: and this government, which had once poſſeſſed the moſt uncontrouled dominion over the minds of men, now fell without a ſtruggle. General Berthier, at the head of a body of French and Ciſalpine troops, encountered no oppoſition in his march
322 The papal government overturned. to Rome, where he overturned the government of the Pope, and proclaimed the ſovereignty of the Roman people, with circumſtances of wanton inſult; which convey a ſtriking example of French humanity and French delicacy.

"That the head of the church might be made to feel with more poignancy his humiliating ſituation, the day choſen for planting the tree of liberty on the Capitol was the anniverſary of his election to the ſovereignty. Whilſt he was, according to cuſtom, in the Siſtine chapel celebrating his acceſſion to the papal chair, and receiving the congratulations of the cardinals, Citizen Haller, the commiſſioner-general, and Cervoni, who then commanded the French troops within the city, gratified themſelves in a peculiar triumph over this unfortunate potentate. During that ceremony they both entered the chapel, and Haller announced to the ſovereign Pontiff on his throne, that his reign was at an end.

"The poor old man ſeemed ſhocked at the abruptneſs of this unexpected notice, but ſoon recovered himſelf with becoming fortitude; and when General Cervoni, adding ridicule to oppreſſion, preſented him the national cockade, he rejected it with a dignity that ſhewed he was ſtill ſuperior to his misfortunes. At the ſame time that his Holineſs received this notice of the diſſolution of his power, his Swiſs guards were diſmiſſed, and republican ſoldiers put in their place." 323 Cruel treatment of the Pope.

He was himſelf removed to the territory of Tuſcany, where he reſided in much obſcurity, till his enemies, driven from Rome in their turn, thought fit to carry him ſtill farther from his capital, to end his days beyond the Alps.

In the mean time, the Roman ſtates were converted into a republic after the French model; excepting that the ancient appellations of *conſuls*, *ſenators*, and *tribunes*, were adopted, inſtead of the new names of a *Directory* and *two Councils* (D). But this oſtentatious grant of freedom was rendered completely illuſory, by a condition 324 Roman republic.

(D) The character of a nation, like that of an individual, will not perhaps admit of a ſudden and total change. This remark is exemplified in the French; who, even when they affect to aſſume the ſtern manners of Republicans, cannot diveſt themſelves of their frivolous and fantaſtical turn, and of that fondneſs for pomp and ſhow by which they were always diſtinguiſhed. The following account of the re-eſtabliſhment of the Roman Republic, by an author of reſpectability who witneſſed the ſolemn farce, will amply confirm the truth of our aſſertion.

"That the regenerated Roman people might be conſtitutionally confirmed in their newly-acquired rights, a day was ſet apart ſolemnly to renounce their old government, and ſwear fidelity to the new. For the celebration of this ſolemnity, which took place on the 20th of March, an altar was erected, in the middle of the piazza of St Peter's, with three ſtatues upon it, repreſenting the French, Ciſalpine, and Roman Republics. Behind the altar was a large tent, covered and decorated with ſilk of the Roman colours, ſurmounted with a red cap, to receive the deputies from the departments who had been ſummoned to aſſiſt. Before the altar was placed an open orcheſtra, filled with the ſame band that had before been employed to celebrate the funeral honours of Duphot. At the foot of the bridge of St Angelo, in the piazza di Ponte, was erected a triumphal arch, upon the general deſign of that of Conſtantine, in the Campo Vacino, on the top of which was alſo placed three coloſſal figures, repreſenting the three republics. As a ſubſtitute for bas-reliefs, it was painted in compartments in *chiara ſcura*, repreſenting the moſt diſtinguiſhed actions of Bonaparte in Italy. Before this arch was another orcheſtra.

"The ceremony in the piazza began by the marching in of the Roman legion, which was drawn up cloſe to the colonnade, forming a ſemicircular line; then came French infantry, and then cavalry, one regiment after another alternately, drawn up in ſeparate detachments round the piazza. When all was thus in order, the conſuls made their entrance, on foot, from the Vatican palace, where they had robed themſelves, preceded by a company of national troops and a band of muſic; and if the weather had permitted, a proceſſion of citizens, ſelected and dreſſed in *gala* for the occaſion, from the age of five years to fifty, were to have walked two and two carrying olive branches; but an exceſſively heavy rain prevented this part of the ceremony.

"Before the high altar, on which were placed the ſtatues, there was another ſmaller one with fire upon it. Over this fire the conſuls, ſtretching out their hands, ſwore eternal hatred to monarchies. and fidelity to the republic; and at the concluſion, one of them committed to the flames a ſcroll of paper he held in his hand, containing a repreſentation of all the inſignia of royalty, as a crown, a ſceptre, a tiara, &c.; after which the French troops fired a round of muſketry; and, at a ſignal given, the Roman legion raiſed their hats in the air upon the points of their bayonets, as a demonſtration of attachment to the new government: but there was no ſhouting—no

French Revolution, 1798. tion annexed to it, that for ten years the French General should possess a negative upon all laws and public acts. At first, however, the conquerors took care to place the government in the hands of the most respectable persons in the state favourable to democracy. But these men finding that they were merely to be employed as tools to plunder their fellow-citizens, for the emolument of their northern masters, soon renounced their odious dignities, and were succeeded by men of more compliant characters, and less scrupulous integrity. The whole public property was seized by the invaders, and contributions were levied without end. The property of the cardinals and others who fled was confiscated, and those members of the sacred college who remained were thrown into prisons, from which they could only escape by purchasing their freedom at a high price.

When this was done, and Generals and Commissaries had glutted themselves with wealth, quarrelled about a *just* division of the spoil, mutinied, and dispersed, other unpaid, unclothed, unprovisioned armies from the north, with new appointments, succeeded; and when at length, even by these *constitutional* means, nothing more was to be obtained, and artifice had exhausted every resource, the mask was put under the feet that had been long held in the hand; liberty was declared dangerous to the safety of the republic, the constituted authorities in-

325 Superseded by military despotism. capable of managing the affairs of the state, and military law the only rational expedient to supply their place. Thus at once the mockery of consular dignity was put an end to, the senators sent home to take care of their families, and the tribunes to blend with the people whom they before represented. This new and preferable system began its operations with nothing less important for the general welfare, than seizing the whole annual revenue of every estate productive of more than ten thousand crowns; two-thirds of every estate that produced more than five, but less than ten; and one-half of every inferior annual income.

Even the degenerated Romans could not have submitted to all this, or at least would not have assisted in forging their own chains, had not the same means been employed to eradicate from their minds every moral and religious principle, which had been formerly employed for the same purpose in Paris. In order that the spirit of equality might be more extensively diffused, a constitutional democratic club was instituted, and held in the hall of the Duke d'Altemp's palace. Here the new-born sons of freedom harangued each other on the blessings of emancipation; talked loudly and boldly against all constituted authority; and even their own consuls, when hardly invested with their robes, became the subjects of censure and abuse. The English were held as particularly odious, and a constant theme of imprecation; and this farce was so ridiculously carried on, that a twopenny subscription was set on foot to reduce what they were pleased to call the proud Carthage of the North.

French Revolution, 1798. 326 Methods employed to corrupt the Roman youth.

If this foolish society had had no other object in view than spouting for each other's amusement, bowing to and kissing a bust of Brutus which was placed before the rostrum (a ceremony constantly practised before the evening's debate), it would have been of little consequence to any but the idle, who preferred that mode of spending their time; but it had other objects of a very different tendency, more baneful, and more destructive to the peace and morals of society—that of intoxicating young minds with heterogeneous pinciples they could not understand, in order to supersede the first laws of nature in all the social duties; for there were not wanting men who knew how to direct the folly and enthusiasm of those who did not know how to direct themselves. Here they were taught, that their duty to the Republic ought ever to be paramount to every other obligation; that the illustrious Brutus, whose bust they had before them, and whose patriotic virtue and justice ought never to be lost sight of, furnished them with the strongest and most heroic example of the subordination of the dearest ties of humanity to the public good; and that, however dear parental affection might be, yet, when put in competition with the general welfare of society, there ought not to be a moment's hesitation which was to be preferred.

This sort of reasoning might perhaps have done no harm to the speculative closet metaphysician, who might have had neither father, nor mother, nor brother, nor sister, nor a chance of ever being thrown in the way to reduce his theory to practice; but with a people who knew of no other ties but such as depended on their religion and their natural feelings, without having been previously educated to discriminate, how far their reason might be deluded by sophistry, or upon what causes

no voluntary signs of approbation; nor do I believe that there ever was a show, in which the people were intended to act so principal a part, where so decided a tacit disapprobation was given as on this occasion.

"After the ceremony was concluded, the French officers, with the consuls and deputies from the departments, dined together in the papal palace on Monte Cavallo, and in the evening gave a magnificent ball to the exnobles and others, their partizans, which was numerously attended, yet with an exception to the houses Borghese, Santacroce, Altemp, and Cesarini: I believe not one distinguished family was present from desire or inclination: but it was now no longer time to accumulate additional causes for oppression: and he who hoped to save a remnant of his property, avoided giving occasion for personal resentment. At night the dome of St Peter's was illuminated, with the same splendour as was customary on the anniversary of St Peter's day. This was the second time of its illumination since the arrival of the French, having been before displayed on the evening of the solemn fete to honour the manes of Duphot, which, though not quite so opportune, was done to gratify the officers that were to leave Rome on the morrow.

"The day after this federation, the French published the Roman constitution in form, which was only a repetition of the one given to the unfortunate Venetians, consisting of 372 articles, and which I think unnecessary to transcribe, as it would only be giving what we have already had from time to time in translations made from their own."—*Duppa's Journal of the most remarkable occurrences that took place in Rome*, upon the Subversion of Ecclesiastical Government in 1798.

French Revolution, 1798.

causes the permanent good of society depended, it had the most direct tendency to generate the worst passions, and to annihilate the best.

Young men were thus initiated to lose all respect for their parents and relations, and even encouraged to lodge information against them, with the hopeful prospect of being considered as deserving well, of what they were pleased to denominate, the republic; and by thus weakening or destroying the bonds of affection, the way was made smooth and easy to the destruction of every thing like what, in a state of civilization, is called character; doubtless, in order to prepare them the better to become the faithful agents of those whom they were thus educated to serve.

327 Monuments of ancient art exposed to sale.

The most remarkable curiosities of this celebrated city had already been conveyed to Paris; and as national vanity had now given place to avarice in the minds of the Directory, the remaining monuments of ancient or of modern art, with which Rome abounded, were sold by public auction. Advertisements (E) were sent through Europe, offering passports to the natives of countries at war with France, if they should wish to become purchasers; and thus the wealthier inhabitants of the Roman territory not only saw themselves subjected to severe exactions, but they beheld with cruel mortification those objects now given up as a prey to vulgar speculation, and dispersed over the world, which had so long rendered their city the resort of all nations.

Such was the progressive conduct of the *Great Nation* towards an injured and oppressed people, whose happiness and dearest interests were its first care, and to whom *freedom* and *liberty* had been restored, that they might know how to appreciate the virtue of their benefactors, and the inestimable blessings of independence.

328 French ingratitude to Switzerland.

More sanguinary scenes were, in the meanwhile, taking place in Switzerland. That country had remained neutral during the contest in which France had lately been engaged; and had thus protected the weakest portion of her frontier, while the rest of it was assailed by the combined forces of Europe. The merit of this service was now forgotten, and the Directory resolved to render Switzerland one of their tributary states. Ambitious nations have in all ages found it an easy matter to devise apologies for invading the territory of their neighbours. The wealthier branches of the Swiss confederacy were in general governed by hereditary aristocracies. Some of the cantons had no government within themselves, but were the subjects of neighbouring cantons. In consequence of this circumstance, and of the contending privileges of different orders of men, popular insurrections were more frequent in Switzerland than in any country in Europe, though none was more equitably governed. When an insurrection took place in one canton, its government was frequently under the necessity of soliciting the aid of the government of an adjoining canton, or even of the neighbouring monarchs of France or Sardinia, to enable it to subdue its own rebellious subjects. A dangerous precedent was thus established; and as the French kings had formerly interfered in favour of the rulers, the republican Directory now interfered in favour of the subjects. The canton of Berne was sovereign of the territory called the *Pays de Vaud*. In this district discontents had always existed; and an insurrection, under the countenance of the French Directory, broke out towards the end of the year 1797. The government of Berne saw the dangerous nature of its own situation; and on the 5th of January issued a proclamation, commanding the inhabitants of the Pays de Vaud to assemble in arms, to renew their oath of allegiance, and to reform every abuse that might appear to exist in their government. A commission was at the same time appointed by the Senate or Sovereign Council at Berne to examine all complaints, and to redress all grievences. The proceedings of this commission, however, did not keep pace with the popular impatience; and the insurgents began to seize the strong places in their country. The government of Berne now resolved to reduce them by force, and sent troops against them; but their commander Weiss appears to have acted with much hesitation, if not with treachery, In the mean time, a body of French approached under General Menard. He sent an aid de camp with two hussars, with a message to General Weiss. On the return of the messengers, an accidental affray took place, in which one of the hussars was killed. This was magnified into an atrocious breach of the law of nations. The French advanced; and by the end of January obtained possession of the whole Pays de Vaud. Still, however, the government of Berne attempted to preserve peace, while it endeavoured to prepare for war. The soldiers who had killed the French hussar were delivered up, negociations were begun, and a truce entered into with General Brune, who succeeded Menard in the command of the French troops in the Pays de Vaud. As internal commotions were breaking out in all quarters, an attempt was made to quiet the minds of the people, that they might be induced to unite against the threatened invasion. Fifty two deputies from the different districts were allowed to sit in the Supreme Council of Berne, and a similar measure was adopted by the cantons of Zurich, Lucerne, Fribourg, Soleure, and Schaff hausen. An army of 20,000 men was at the same time assembled, and entrusted to the command of M. d'Erlach, formerly field marshal in the French service. But disaffection greatly prevailed in this army, and the people could not be brought to any tolerable degree of union. The French knew all this, and demanded a total change of government. M. d'Erlach, dreading the increasing tendency to desertion among his troops, requested leave to dissolve the armistice. It was granted by the government, and immediately recalled. But the French now refused to negociate; and on the 2d of March, General Schawenberg, at the head of 13,000 men, entered Soleure.

329 Undecided conduct of the magistrates of Berne.

(A) A copy of an advertisement, issued on this occasion by what was called *The Administration of Finances and Contributions of the French Republic in Italy*, is to be found in *Nicholson's Journal of Philosophy, Chemistry, and the Arts, for May* 1798. The advertisement is dated at Rome, 28th Feb. 1798. A copy of it was sent by Hubert, the agent of the French administrators, to Mr Trevor the British minister at Turin, and by him was transmitted to England.

French Revolution, 1798.

Solcure. Friburg was afterwards reduced by Brune, and the Swifs army retreated. The government of Berne was in confternation, and decreed what was called the *landfturm*, or rifing of the people; which, in cafes of emergency, was authorifed by their ancient cuftoms.

330 Conſternation of the government, and capitulation of Berne.

The people accordingly affembled; and their firft act was to diffolve the government, and to offer to difmifs the army, on condition that the French troops fhould proceed no farther. This offer was refufed, unlefs a French garrifon fhould be received into Berne, and the invaders continued to advance. The regular troops under M. d'Erlach were reduced by defertion to 14,000. The rifing of the people had indeed fupplied him with numbers, but there was no time for arranging them. On the 5th of March he was attacked, and driven from the pofts of Newenbeg and Favenbrun. He rallied his troops, however, at Uteren, where they made a ftand for fome time. They renewed the conteft at Grauholtz without fuccefs, and were driven from thence about four miles farther to the gates of their capital. Here the Swifs army made a laft and bloody effort. Being completely routed, they murdered many of their officers in defpair, and among others their commander M. d'Erlach. The flaughter on both fides is faid to have been nearly equal; but the French fucceeded in obtaining poffeffion of Berne by capitulation on the evening of the day on which thefe battles were fought. Upon the capture of this city, the other more wealthy and populous ftates fubmitted to the French; but the poorer cantons, who had leaft to lofe, made a terrible effort in defence of their fmall poffeffions, and the independence of their country. They even at firft compelled Schawenberg to retire with the lofs of 3000 men; but were at laft overpowered by the fuperior numbers and military fkill of the French army.

331 Switzerland treated as a conquered country.

Switzerland was treated as a conquered country. Its public magazines were feized by the French, heavy contributions were levied, and a new conftitution, in imitation of that of France, was impofed.

While the Directory continued to encroach upon the independence of other nations, they were not likely to refpect the freedom of their countrymen at home. In the month of April, a third of the legiflature was changed. Francis de Neufchateau went out of the Directory by ballot, and Treilhard was chofen in his ftead. The Directory had made great efforts to influence the elections in favour of their friends, but with little fuccefs. They prepared therefore to preferve the legiflature in fubjection to them by a new violation of the conftitution.

332 The Directory violates the conftitution.

On the 2d of May they complained to the Council of Five Hundered of the plots of anarchifts and royalifts; by which they alleged that the elections had in many places been made to fall on men hoftile to the Republic. On the 7th a committee made a report upon this meffage, and propofed that the proceedings of many electoral affemblies fhould be totally or partially annulled, according to the characters of the perfons they had chofen. General Jourdan, and fome others, ventured to oppofe this plan as utterly inconfiftent with the freedom of election, and as proceeding upon alleged intrigues of confpirators againft the Republic, while no confpiracy had been proved to exift. But the majority agreed to the propofal of the committee, and arbitrarily annulled the whole elections in fix or feven departments, befides the particular elections of a great number of individuals.

333 Plan an expedition to Egypt and India.

The Directory now carried into effect the moft fatal of all their projects, that of fending a powerful army to the eaft to feize upon Egypt, and from thence to attack the empire which Britain has acquired in India. The treaty with Auftria had no fooner been figned at Campo Formio, than the Directory excited the expectation of France and of all Europe, by loudly proclaiming their determination to invade Great Britain. They fent troops into their own weftern departments, called them the *Army of England*, and appointed Bonaparte their commander in chief. This officer, in the mean time, had refided during the winter at Paris. Here he feems to have endeavoured to guard againft the jealoufy of government, and the envy of individuals, by paffing his time in retirement, and affuming the character of a man of letters. He procured himfelf to be elected a member of the National Inftitute; but fo feldom did he appear abroad, that when he attended fome of its public fittings his perfon was altogether unknown to the fpectators. Greedy of renown, but aware that it ultimately depends upon the labours and the approbation of the learned, he never failed, when called into military fervice, to remind this order of men of his alliance with them, by adding to his name at all proclamations and difpatches the defignation of *Member of the National Inftitute*.

Whether the expedition to Egypt was now fuggefted by Bonaparte himfelf, or whether it was not a fnare by which the prefent rulers of France impofed upon the vanity of an enterprifing young man, to enable them to get quit of him and his veteran army, is not known. It is very poffible, however, that Bonaparte might neither be the devifer nor the unconfcious victim of this plan; but that he might account himfelf more fafe abroad, upon the moft hazardous expedition, than expofed at home to the malice of a government that had become jealous of his reputation, and was by no means fcrupulous in its conduct.

334 Preparations for it conducted with fecrecy.

The projected invafion of Egypt was conducted with much fecrecy. The world was amufed with tales of monftrous rafts to be conftructed to convey the army of England over into Britain. To favour the deception, Bonaparte made a journey to the weftern coaft. In the mean time, the fleet was preparing at Toulon, and troops affembling in its neighbourhood. When all was in readinefs, Bonaparte embarked with 40,000 of the troops that had fought in Italy. On the 9th of June he arrived at the ifland of Malta, and contrived to quarrel with the Grandmafter, becaufe he refufed to admit fo large a fleet all at once into his ports to water. The French General immediately landed his troops in different quarters, and endeavoured to reduce the ifland. The knights were divided into factions. Many of them, as is now well known, were of the order of Illuminati, and of courfe prepared to act the part of traitors.

335 Conqueft of Malta.

After making a very feeble refiftance, the Grandmafter propofed a capitulation; and thus was treacheroufly furrendered, in a few days, a fortrefs which, if defended by faithful troops, might have held out for as many weeks againft all the forces of the French Republic. Bonaparte, after leaving a garrifon of 4000 men in the ifland, failed on the 21ft of June for Alexandria.

336 Admiral Nelfon fails in queft of Bonaparte.

In the mean time, Rear admiral Nelfon, who, in the ftation of Commodore, had fignalized himfelf in a very high degree under Lord St Vincent, had been difpatched in queft of him from the Britifh fleet, which ftill blockaded Cadiz. Not knowing the object of the French expedition, the Britiſh Admiral ſailed firſt to Naples; and having there been informed of the attack upon Malta, he directed his courſe to that iſland. By the time he arrived there, however, Bonaparte had departed. Conjecturing now that Alexandria might be the deſtination of the French troops, he ſailed thither; but they had not been ſeen in that quarter, and he therefore went eagerly in ſearch of them to other parts of the Mediterranean Bonaparte, in the mean while, inſtead of ſteering in a direct line for Alexandria, had proceeded ſlowly with his immenſe train of nearly 400 tranſports, along the coaſt of Greece, till he arrived at the eaſtern extremity of the iſland of Candia. Here he ſuddenly turned ſouthward; and in conſequence of his circuitous courſe, did not arrive at the coaſt of Egypt till Admiral Nelſon's fleet had left it. He landed his troops; and on the 5th of July took by ſtorm the city of Alexandria. The inhabitants defended themſelves very deſperately, but without ſkill; and for ſome time a ſcene of barbarous pillage and maſſacre enſued. The tranſports that had conveyed the army were now placed within the inner harbour of Alexandria, and the ſhips of war under Admiral Brueys caſt anchor in a line cloſe along the ſhore of what proved to them the fatal Bay of Aboukir. The army proceeded to the Nile, and aſcended along the banks of that river, ſuffering great hardſhips from the heat of the climate. They were met and encountered by the Mamalukes, or military force that governed Egypt; but theſe barbarians could not reſiſt the art and order of European war. Cairo was taken on the 23d of July. On the 25th another battle was fought; and on the 26th the Mamalukes made a laſt effort in the neighbourhood of the celebrated pyramids for the preſervation of their empire. Two thouſand of them were killed on this occaſion, 400 camels laden with their baggage were taken, along with 50 pieces of cannon.

337 Conqueſts of Bonaparte in Egypt.

A proviſional government was now eſtabliſhed in Egypt. Proclamations were iſſued in the Arabian tongue, declaring that the French were friendly to the religion of Mahomet, that they acknowledged the authority of the Grand Signior, and had only come to puniſh the crimes committed by the Mamalukes againſt their countrymen trading to Egypt. Thus far all had gone well; but on the 1ſt of Auguſt the Britiſh fleet appeared at the mouth of the Nile; and the ſituation of the French fleet having been diſcovered, Admiral Nelſon prepared for an attack. In number of ſhips the fleets were equal; but in the number of guns and weight of metal the French ſquadron had the ſuperiority. It was drawn up, too, in a form which ſuggeſted to its ill-fated commander the idea of its being invincible; but remaining at anchor, the Britiſh Admiral was enabled, by running ſome of his ſhips between thoſe of the enemy and the ſhore, to ſurround and engage one part of their fleet, while the reſt remained unemployed and of no ſervice. In executing this plan of attack, a Britiſh ſhip, the Culloden, run aground; but this accident only ſerved as a beacon to warn the others of the ſpot that ought to be avoided. The battle commenced at ſunſet, and was continued at intervals till daybreak. At laſt, nine ſail of the French line were taken; one ſhip of the line was burned by her own commander; a frigate was burned in the ſame manner, to prevent her being taken. The French Admiral's ſhip L'Orient took fire, and blew up during the action, and only a ſmall number of her crew of 1000 men eſcaped deſtruction. Two French ſhips of the line and two frigates were ſaved by a timely flight (F).

338 Admiral Nelſon attacks and deſtroys the French fleet.

339 Conſequences of his victory.

No naval engagement has in modern times produced ſuch important conſequences as this. The unexampled military efforts made by France had gradually diſſolved the combination which the princes of Europe formed againſt her. By the train of victories which Bonaparte had gained, the houſe of Auſtria, her moſt powerful rival, had been humbled and intimidated. The whole continent looked towards the new Republic with conſternation; and when the Directory ſeized upon Rome and Switzerland, none were found hardy enough to interpoſe in their favour. The current of affairs was now almoſt inſtantaneouſly altered. Europe beheld Bonaparte, with his *invincible* army, exiled from its ſhores, and ſhut up in a barbarous country, from which the triumphant navy of Britain might for ever prevent his return. The enemies of France could not beforehand have conceived the poſſibility of the event which was now realiſed; and the hope was naturally excited of being able to form a new and more efficient coalition againſt a government which had ſo groſsly abuſed the temporary proſperity it had enjoyed. The northern powers began to liſten to the propoſals made to them by Great Britain for commencing hoſtilities anew, and the Italian ſtates prepared to make another effort for independence. The court of Naples in particular openly avowed its joy on account of the recent deſtruction of the French fleet. The king himſelf put to ſea to meet Admiral Nelſon on his return from the Nile. Illuminations took place in the capital, and vigorous preparations were made for war. The Grand Signior, who had poſſeſſed of late little authority in Egypt, and might perhaps have been induced to relinquiſh his claims on that province rather than engage his decaying empire in war, now entered into cloſe alliance with Britain, and engaged in hoſtilities againſt the French. Tippo Sultan had ſtipulated for the aid of a French army againſt the Britiſh in India; but Bonaparte, on taking poſſeſſion of Suez and the other Egyptian ports on the Red Sea, found no ſhipping there fit to tranſport his army to the Indian peninſula. Inſtead of proceeding therefore upon any ſplendid ſcheme of farther conqueſt, he was compelled to remain in his preſent ſituation, and to contend for exiſtence againſt the whole force of the Ottoman empire.

340 Rebellion in Ireland.

The French at this time did not venture to ſend forth any large fleet upon the ocean; but wherever their ſmaller ſquadrons appeared, the fortune of Britain overpowered them there no leſs than it had done in the Mediterranean. They had long promiſed aid to the diſaffected party in Ireland; but weary of fruitleſs expectation, the Iriſh had during this ſummer broken out into rebellion, without waiting the arrival of the troops whom the Directory had engaged to ſend to their aſſiſtance. While the rebellion was at its height, and although the inſurgents for ſome time occupied the ſea port of Wexford, the French did not arrive. Afterwards,

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(F) The two ſhips of the line and one of the frigates have been ſince taken.

French Revolution, 1798. wards, however, when the rebellion had been totally subdued, they attempted to elude the vigilance of the British fleet, and to land men in small parties. On the
341 22d of August, General Humbert came ashore at Killala, at the head of about 1100 men. Even this small party might have been dangerous had it arrived a month earlier; and it actually produced very serious alarm. It consisted of men selected with great care, and capable of enduring much fatigue. They were joined by a few of the most resolute of the discontented Irish in the neighbourhood, and speedily defeated General Lake, who advanced against them with a superior force, taking from him six pieces of cannon. They next marched in different directions, for the purpose of raising the people, and maintained their ground in the country during three weeks. Finding, however, that he was not seconded by additional troops from France, that the rebellion in Ireland had been fully subdued, and that 25,000 men under Lord Cornwallis were closing round him, Humbert dismissed his Irish associates; and four days thereafter, having encountered one of the British columns in his march, he laid down his arms. Now, when it was too late, the Directory was very active in sending troops towards Ireland; but all their efforts
342 were defeated by the superiority of the British navy. On the 12th of October, Sir John Borlase Warren took La Hoche, a ship of 84 guns, and four frigates, attempting to reach Ireland with nearly 3000 men on board. The other ships belonging to the French squadron, which conveyed 5000 men in all, contrived to make their escape by sailing round by the north of the island. On the 20th of the same month another frigate bound for Ireland was taken; and the French finding that the sea was completely occupied by the British fleet, were at last compelled to desist from their enterprise.

Feebly supported by the Directory.

Whose efforts are defeated by the British navy.

Ever since the treaty of Campo Formio had been concluded, a congress of ministers from the French Directory, and from the German princes, had been negociating at Rastadt a treaty between France and the empire. As these negociations terminated in nothing, and were tedious and uninteresting during their progress, it is unnecessary to enter into a detail of the steps by which they were conducted. The intended result of them had been previously arranged between the Emperor and the Directory in the secret convention of
343 Campo Formio, which has been already mentioned. That the articles of this convention might be concealed, the French ministers at Rastadt formerly brought forward their proposals in succession for the discussion of the German deputies. The French demanded that the Rhine should be the boundary of their Republic. The Germans resisted this. References were made to the diet of Ratisbone, and long discussions and negociations took place among the different princes. When it was found that little was to be expected from the protection of Austria, the German deputies at Rastadt were instructed to offer one half of the territory demanded. This offer was refused, and new negociations took place. The other half was at last yielded up, and a long discussion commenced about the debts due by the ceded territory, which the French refused to pay. The tolls upon the river, and upon the rivers flowing into the Rhine, also gave rise to much altercation. It was even a matter of no small difficulty, after all, to determine the precise boundary of France; whether her territory should extend to the left bank, the right bank, or the thalweg, that is, the middle of the navigable channel of the river. It became also a question how those princes ought to be indemnified who lost their revenues or territories by the new acquisitions of France; and it was at length agreed that they should receive portions of the ecclesiastical estates in Germany.

Negociations at Rastadt.

These discussions, conducted with endless formality and procrastination, still occupied the congress at Rastadt: but it now became gradually more probable that 344
no treaty would be concluded at that place. Austria began to strengthen her armies in all quarters. Russia, that had hitherto avoided any active interference in the contest, placed a large body of troops in British pay, and sent them towards the German frontiers. The king of Naples avowedly and eagerly prepared for war. This impatient monarch, resolving to attack without delay the French troops who occupied the Roman territory, procured General Mack and other officers from the court of Vienna to assume the command of his army. Without waiting, however, till Austria should commence the attack, he rashly began the war alone and unaided, excepting by the British fleet, and thus drew upon himself the whole force of the French Republic. The Directory did not suspect such imprudent conduct on the part of this prince; and accordingly, when General Mack entered the Roman territory, at the head of 45,000 men, the French troops in that quarter were altogether unequal to the contest. A French ambassador still resided at Naples when this event took place, and war was not declared. When the French General Championet complained of the attack made upon his posts under these circumstances, he was informed in a letter by General Mack, that the king of Naples had resolved to take possession of the Roman territory, having never acknowledged its existence as a Republic; he therefore required the French quietly to depart into the Cisalpine states; declaring, that any act of hostility on their part, or their entrance into the territory of Tuscany, would be regarded as a declaration of war. Championet finding himself unable to resist the force 345
now brought against him, actually evacuated Rome. He left, however, a garrison in the castle of St Angelo, and endeavoured to concentrate whatever troops he could hastily collect in the northern extremity of the Roman state. Towards the end of November, General Mack entered Rome without opposition.

Preparations for war on the Continent.

The Neapolitans take possession of Rome.

When these events came to be known at Paris, war was immediately declared against the king of Naples, and also against the king of Sardinia. This last prince had made no attack upon France; but he was accused by the Directory, in their message to the Councils, of *disaffection* to the Republic, and of *wishing* to join the king of Naples in his hostile efforts. This accusation could not well be false. From the period of Bonaparte's successful irruption into Italy, the king of Sardinia had felt himself placed in the most humiliating circumstances; his most important fortresses were occupied by the French; they levied in his country what contributions they thought fit; and when they recently required him to receive a garrison into his capital, he 346
found himself unable to resist the demand. Even now, when they performed the useless ceremony of declaring war, he could make no effort in his own defence, and quietly

Hard fate of the king of Sardinia.

French Revolution, 1798. quietly gave them a formal resignation in writing of his whole continental dominions, consenting to retire to the island of Sardinia.

In the mean time, the contest with Naples was soon decided. The French on their retreat were much harassed by the people of the country. The Neapolitan troops regarded them with such animosity, that they scarcely observed the modern rules of war towards the prisoners who fell into their hands. Even their leaders seemed in this respect to have forgotten the practice of nations; for when General Bouchard, by order of General Mack, summoned the castle of St Angelo to surrender, he declared, that he would consider the prisoners of war and the sick in the hospitals as hostages for the conduct of the garrison; and that for every gun that should be fired from the castle, a man should be put to death. It cannot well be imagined that the Neapolitan officers would have acted in this vehement manner, had they not expected countenance and support from the immediate co-operation of Austrian troops. In their hopes from this quarter, however, they were completely disappointed.

347 Naples conquered by the French.

Mindful of her recent calamities, and attentive only to her own aggrandisement, Austria seems still to have expected more from negociation than from war, and the territory of Naples soon fell into the hands of the French. Such indeed was the terror of the French name in Italy, or such was the disaffection or cowardice of the Neapolitan troops themselves, that they were beaten by one-fourth of their number in different engagements, at Terni, Porto Fermo, Civita Castellana, Otricoli, and Calvi. At the commencement of the contest a body of Neapolitans, with the assistance of the British fleet, had been landed at Leghorn, for the purpose of taking the French in the rear: but they, disregarding this attempt on the part of such an enemy, pressed on towards Naples. By degrees, General Mack's army being reduced by the result of the battles which it fought, and by desertion, to 12,000 men, he found it necessary to advise the king and royal family of Naples to take refuge on board the British fleet. They did so; and arrived at Palermo, in Sicily, on the 27th of December, in the British Admiral Lord Nelson's ship. General Mack, in the mean time, requested an armistice, to afford an opportunity for making peace; but this was refused. Being driven from Capua, which is the last military post of any strength in the Neapolitan territory, and his life being in no small danger from the disaffection of his own troops, he at last found it necessary to seek for safety, by surrendering himself, along with the officers of his staff, to the French General. The governor of Naples, in the mean time, offered to the French a contribution in money, if the commander in chief would consent to avoid entering that city. The offer was accepted, and the invading army remained at Capua. General Serrurier, on the 28th of December, at the head of a column of French troops, expelled the Neapolitans from Leghorn, and took possession of that place. So far as the efforts of regular armies are to be considered, the war might now therefore be regarded as brought to a termination; but the French had speedily a new and unusual enemy to contend against.

1799. From the mildness of the climate, and the fertility of the soil, human life can be sustained in the southern parts of Italy with fewer efforts of industry than in almost any other country in Europe. Hence arises a general propensity to idleness, which is increased by the numerous charitable institutions to which the Roman Catholic religion gives rise. In the city of Naples there had long existed a body of persons under the denomination of *Lazzaroni* or Beggars, amounting to the incredible number of from thirty to forty thousand men, who did nothing, and subsisted merely by charity, or by such shifts as occasionally occurred to them. One of these frequently was the menacing the state with an insurrection, in case their wants were not instantly supplied; which usually drew from a feeble administration very liberal distributions of money and provisions. On the present occasion they demonstrated abundance of loyalty; but the king had thought fit to avoid entrusting his safety to such defenders. During the confusion which followed the flight of the court and the approach of the French army, the Lazzaroni became mutinous. They heard that the French abolished, wherever they came, all those monasteries and other religious establishments which are the great sources of public charity. The Lazzaroni, therefore, conceived the most violent hatred against them, and against all who were suspected of favouring opinions hostile to royal government. In the beginning of January they began to shew symptoms of discontent, and in a few days broke out into open insurrection. The members of the government left by the king, overcome by habitual terror of the Lazzaroni, consulted merely their own personal safety, and made no effort to preserve the public tranquillity. Prince Militorni had gained considerable applause on account of his vigorous defence of Capua against the French. The Lazzaroni therefore elected him their commander in chief; but he attempted in vain to restrain their violence and love of plunder. They declared hostility against the French and all the advisers of the armistice. They broke open the prisons, and put to death all those who were confined on account of political offences against the royal government.

348 The Lazzaroni rise against the French.

349 Their outrages.

They next spread themselves over the city in search of those persons whom they considered as favourable to the invaders, and committed murder and robbery in all quarters, concluding by burning the houses of those accounted disaffected. An attempt was made by a considerable body of the inhabitants, who thought themselves in the greatest danger, to resist their fury, by fortifying the Convent of the Celestins, and retiring thither; but the Lazzaroni, after encountering the fire of cannon and of musketry, succeeded in storming the place, and destroyed all who had taken refuge there. Their power and their fury were now equally boundless, and the city became in many quarters a scene of massacre and pillage. Prince Militorni, therefore, went to Capua, and requested Championet to rescue Naples from utter ruin by occupying it with his army. For this purpose it was arranged, that a column of French troops should secretly advance by a circuitous march, and suddenly enter the city from the opposite quarter. Before this plan could be fully executed, the Lazzaroni had adopted the daring resolution of attacking the French within the fortifications of Capua. Accordingly two-thirds of them marched out upon this enterprise, and spent the 19th and 20th of January in attempting to take Capua by assault. Multitudes of these men here perished by the artillery of the place; for the French,

French Revolution 1799.

French, to favour the capture of Naples by the party that had been ſent eaſtward for that purpoſe, avoided making any ſally, and remained upon the defenſive. The Lazzaroni at Capua, however, having learned on the 21ſt that a French column had marched to Naples, and approached the gates, ſuddenly returned to the aſſiſtance of their brethern in the capital. They were cloſely purſued by the French; but they had leiſure, nevertheleſs, to barricade the ſtreets, and to form themſelves into parties for the defence of different quarters. A dreadful and ſanguinary conteſt now enſued, which laſted from the morning of the 22d to the evening of the 23d of January. The Lazzaroni, with ſome peaſants who had joined them, diſputed obſtinately every ſpot of ground; and by the energy which they diſplayed, caſt a ſevere reproach upon the feeble and unſkilful government, which had not been able to direct in a better manner the courage of ſuch men. At length, after having been gradually driven from ſtreet to ſtreet, the Lazzaroni rallied for the laſt time at one of the
350 gates of the city, where they were nearly exterminated. The inhabitants rejoiced on account of their own eſcape from immediate ruin; and while the French armies found themſelves become odious in all the other countries which they had entered, they here found themſelves, from the peculiar circumſtances of the caſe, received with unfeigned welcome, in a city which holds the third place in population and ſplendour among the capitals of Europe.

They are nearly exterminated.

This may be regarded as the laſt triumph enjoyed by the Directory. The conſequences of their conduct were now gathering faſt around them. They were deſervedly unpopular at home; not only from the violations they had offered to the conſtitution of their country, but alſo from the manner in which they conducted public affairs in detail. They ſet no bounds to their profuſion, or to the exactions with which their agents vexed the conquered countries. Championnet, aſhamed of the extortions of which the Commiſſaries of the Directory were guilty, attempted in Italy to reſtrain them; and the conſequence was, that, upon the complaint of the commiſſary Taypoult, he was deprived of his command, and thrown into priſon. Scherer, the miniſter of war, was appointed his ſucceſſor. Under him
351 the rapacity of the agents of government, and the embezzlement of the public ſtores, was carried to its height. The members of the armies were ſuffered to decline, that the Directory, the commiſſaries, and the generals, might become rich. Thus the ſtate was left totally unprepared againſt the ſtorm which was now rapidly gathering from abroad. Still, however, France was feared by the neighbouring nations, to whom the preſent ſtate of her internal affairs was obſcurely known. Though an army of 45,000 Ruſſians had advanced to the aid of Auſtria, yet that Cabinet heſitated to declare war. Pruſſia was eagerly ſolicited by Britain to take up arms againſt France, and large pecuniary aid was offered; but Sieyes, the Directory's ambaſſador at Berlin, artfully contrived to defeat this negociation, and to counteract the unpopularity of his country in Germany, by publiſhing the ſecret convention at Campo Formio, which we have already mentioned. This treaty demonſtrated ſo clearly to the German princes the utter unconcern with which their independence and their intereſts were regarded by the head of the empire, that no ſteady co-operation with Auſtria could henceforth be expected from them. The greater number of them, therefore, reſolved to maintain their neutrality under the protection of Pruſſia.

Rapacity of the Directory.

On the 2d of January, the French miniſters at Raſtadt preſented a note to the congreſs, in which they intimated, that the entrance of Ruſſian troops into Germany, if not reſiſted, would be regarded by them as a declaration of war. Some negociation took place in conſequence of this note, but no ſatisfactory anſwer was returned. On the 26th of that month, the ſtrong fortreſs of Ehrenbreitſtein ſurrendered, after having remained under blockade ſince the concluſion of the treaty of Campo Formio. By the poſſeſſion of this place, and of Mentz and Duſſeldorf, France was now rendered very formidable on the Rhine. As ſhe poſſeſſed alſo the ſtrong country of Switzerland, and all the fortified places of Italy, ſhe was well prepared, not only for defence, but for active operation; for it is now known, that the conferences of Raſtadt were purpoſely protracted, by orders from the Directory, till the French armies ſhould be ready to take the field with advantage againſt an enemy whoſe conduct betrayed the moſt culpable tardineſs. At this time Jourdan commanded 352
on the Upper Rhine from Mentz to Huningen; Maſſena occupied with an army the eaſtern frontier of Switzerland towards the Griſon country; Scherer was commander in chief in Italy; Moreau acted as general of a diviſion under him; and Macdonald commanded the troops that occupied the territory of Rome and Naples. But theſe armies that kept in ſubjection, and were now to defend ſo many countries, ſcarcely amounted to 170,000 men in all, and were far outnumbered by the armies which Auſtria alone, without the aid of Ruſſia, could bring into the field. The Directory, however, confiding in the unity of its own plans, in the undecided politics of the court of Vienna, and in the conſequent ſlow movements of the Imperial armies, was eager to renew the war; and the two Councils, on the 13th of March, declared France to be at war with the Emperor of Germany and the Grand Duke of Tuſcany. The war, however, had already been begun. On the 1ſt of March Jourdan croſſed the Rhine at Straſburgh, and occupied ſeveral ſtrong poſitions in Swabia. Manheim was taken, and Philipſburg ſummoned to ſurrender by Bernadotte (G), while St Cyr entered Stutgard. On the 4th of March the Auſtrians croſſed the Lech, under the command of the Archduke Charles, to oppoſe this army. Maſſena advanced into the territory of

War renewed on the Rhine.

(G) This ſummons was conceived in very extraordinary terms, and cannot be accounted for but upon the ſuppoſition that Bernadotte believed the Auſtrian officers infected with French principles. He calls upon the commander of the fortreſs to ſurrender without reſiſtance, and thus violate the truſt repoſed in him by his ſovereign. He tells him, that a diſcharge of his duty would produce the *defection of his officers and men.* He warns him of the folly and danger of leading troops to action *againſt their will;* and, laſtly, he threatens him with *vengeance* if he ſhould *dare to reſiſt!*

French Revolution, 1799. of the Grifons; and furprifing a ftrong body of Auftrians, took them all prifoners, together with their General Auffenburgh, and the whole of his ftaff, after a defperate refiftance under the walls of *Coire*. The reduction of the Grifons was the confequence of this victory.

353 And in Switzerland.

But in order to complete the plan of the French, which was to effect a junction with their two armies, that of Maffena in Switzerland with that of Jourdan in Germany, it was neceffary to carry the important poft of Feldkirch, which was occupied by the Auftrian General Hotze, whofe line extended from the frontiers of the Grifons, to the north eaft by the Vorelberg, to the eaftern extremity of the Lake Conftance. Vigoroufly repulfed in his firft attack, Maffena renewed it, five different times, with frefh forces, and increafed impetuofity. But all could not avail againft the fteady bravery of the Auftrians, who drove back the affailants with immenfe flaughter. The French, however, being in poffeffion of the Grifons, the invafion of the Engadine, and the county of Bormio, by a divifion of the army of Italy cantoned in the Valteline, under the orders of General Cafabianca, was facilitated. The Auftrians, too weak in that quarter to refift them, retreated into the Tyrol, whither they were purfued by the French, who forced fome of the defiles by which the entrance of that country was defended, and extended their deftructive incurfions as far as Glurenz and Nauders.

Meanwhile the van-guard of the main army of the Imperialifts pufhed forward to meet the enemy. On the 20th of March it was attacked by Jourdan, who drove in the outpofts; but on the following day that general was himfelf attacked in the centre of his army, driven from his pofition, and compelled to retire during the night to Stockach. Both parties now prepared for a decifive engagement. On the 24th, the Archduke encamped before Stockach, with his right wing towards Nellenburgh, and his left near Wallenweis. On the 25th at day-break, the French army began the attack. They directed their chief efforts againft the right wing of the Auftrians commanded by General Meerfeldt. The battle was long and obftinate. From five o'clock in the morning till paft one of the afternoon, its termination remained extremely doubtful. The French fucceeded in their attempt againft General Meerfeldt. His pofition was forced, and he retreated into a wood between Liptingen and Stockach. Here he renewed the combat

354 The French are defeated in Swabia,

without fuccefs. He was gradually driven to the extremity of the wood, though it is a German mile in breadth. The left wing of the Auftrians, however, had in the mean time maintained its ground, and reinforcements were fent from it to General Meerfeldt. With the affiftance of thefe he at laft fucceeded in making a ftand, and even obliged the French to retire in their turn. At length, about two o'clock, the French found it neceffary to withdraw from this quarter. The battle, however, was continued in different points till night came on. The French remained upon the ground where they had begun the attack, and they even retained 4000 prifoners whom they had taken during the various movements of the day. The refult of the battle, upon the whole, however, was fatal to their affairs. Their lofs was fo great, and the fuperiority of the Auftrians fo manifeft, that Jourdan dared not to hazard another engagement. On the following day he retired to Weiller near Dutlingen; and finding his army altogether unequal to offenfive operations, he fent back one part of it to cover Kehl and Strafburgh, while he withdrew with the other towards Switzerland. This event compelled Maffena, who was preffing upon Tyrol and the Engadine, to return to the defence of Switzerland. He was immediately intrufted with the chief command of the troops in this quarter, in the room of Jourdan, who was removed. The Auftrians continued to advance in every direction, and immediately occupied the whole of the right, or German fide of the Rhine, from the lake of Conftance to Mentz.

355 And in Italy.

In Italy the fuccefs of the Auftrians was equally confpicuous, notwithftanding the treachery of the French in attacking them before the expiration of the truce. The attempt of the latter to force the advanced pofts of the former, on the 26th of March, at Santa Lucia and Buffelango, was rendered abortive; and at Legnago, the Auftrian general, Kray, obtained a complete victory, and compelled them to feek protection under the walls of Mantua. On the 5th of April, the Auftrians again attacked them in their pofition at Memiruolo, which lies on the road from Mantua to Pefchiera, and compelled them, after an obftinate conflict, once more to retreat. The lofs of the French in thefe different actions was undoubtedly great; but it is probably overrated at 30,000 men killed, wounded, and taken.

The fuccefs of the Auftrians, however, was not cheaply purchafed. Scherer, who commanded the French army, gained over them, at firft, fome advantages, which, had he known how to improve them, might have given a different turn to the tide of affairs. One divifion of his army had actually forced the Auftrian pofts on the 26th of March, and taken 4000 prifoners; but the other divifion being repulfed, he withdrew his troops from their advanced pofition, and thus relinquifhed the advantage which he had gained. Even on the 5th of April, Moreau's divifion performed prodigies of valour, and took, it has been faid, 3000 prifoners; but from the injudicious difpofitions which had been made by Scherer, that general was not fupported, and the victory of the Auftrians was complete. Kray now quickly drove the French from the Mantuan, and compelled them, after having fuftained new loffes, to relinquifh their ftrong holds on the Mincio and the Adige, and to retreat to the Adda.

356 Moreau fortifies his camp.

On the banks of this river, rendered remarkable for the dear bought victories which Bonaparte had obtained at the bridge of Lodi, the French general Moreau, to whom the Directory had given the chief command of their army, prepared to make a vigorous defence. The military talents of this man had been rendered unqueftionable by his celebrated retreat through a hoftile country, and before a victorious army ably commanded. On the prefent occafion he did not belie his former character. Nothing that could give courage or confidence to his troops was neglected. Entrenchments were thrown up wherever the river was confidered as paffable; and a fituation, remarkably ftrong by Nature, was ftrengthened by every means which art could fupply.

Before this period, a confiderable body of Ruffians had joined the Imperialifts; and the chief command of the allied army was now affumed by Field Marfhal Suwarrow Rimnifki. This celebrated leader, whofe character

French Revolution, 1799.

racter every democrate labours to miſrepreſent, had entered into the army at the age of twelve, and riſen from the ranks to the ſtation which he now holds, of Generaliſſimo of the Ruſſian armies. Poſſeſſed of ſtrong natural talents, he had likewiſe the benefit of an excellent education, and is ſaid, by thoſe who are perſonally known to him, as well as acquainted with the ſtate of literature in Ruſſia, to be one of the beſt claſſical ſcholars of all the natives of that great empire. He had ſtudied, in early life, mathematics and natural philoſophy, as branches of ſcience abſolutely neceſſary to the man whoſe higheſt ambition is to become a great commander; and his knowledge of the learned, as well as of the faſhionable languages, has enabled him to avail himſelf of all that has been written either by the ancients or the moderns on the art of war. This art has indeed been his chief ſtudy from his youth; it has been at once his buſineſs and his amuſement.

357 [M]arſhal [S]uwarrow

Poſſeſſed with his countrymen, in general, of the moſt undaunted courage, and formed by Nature to endure the greateſt fatigue, it is not ſurpriſing, that with all theſe advantages Suwarrow ſhould have long ago acquired the character of one of the ableſt generals of his time. It is indeed true, that, till the opening of the campaign of 1799, he had diſtinguiſhed himſelf only againſt the Turks, whom we are too apt to deſpiſe, and againſt the Poles when divided among themſelves; but let it be remembered, that the enthuſiaſtic courage of thoſe ſame Turks had found employment for the talents of ſome of the ableſt generals in Europe, a Laudohn and a Cobourg; and that the Poliſh armies which Suwarrow ſubdued were united by the ſtrongeſt of all ties—the knowledge that they muſt conquer or periſh. All this was ſo well known to Frederic the Great, that he held the military talents of the Ruſſian hero in the higheſt eſteem; and the attention of all Europe was now turned towards the quarter where thoſe talents were to be exerted in the ſupport of ſocial order, and of every thing which ennobles man. His operations in Italy did not diſappoint the higheſt expectations which had been formed of them. At an age conſiderably above ſixty, he began a campaign not leſs remarkable for its activity than any which had gone before it ſince the commencement of the French revolution. We are by no means prepared, however, to do juſtice to the various military efforts which were now made, or to explain clearly the means employed to inſure ſucceſs. If the work entitled the *Hiſtory of Suwarrow's Campaigns* be deſerving of credit, the ſuperiority of that commander over his rivals and opponents ſeems to have at all times conſiſted principally in the promptitude with which he formed his plans, and the rapidity with which he carried them into execution. It is likewiſe ſaid to be a maxim of his, always to *commence* the attack when he ſees a battle inevitable, from the perſuaſion that the ardour of the attacking army more than counterbalances the advantage of ground, if that advantage be not very great. Such was certainly the principle upon which he acted at preſent.

358 [At]tacks [hi]m in his [e]ntrench[me]nts,

On the 24th of April the combined army advanced to the Adda; and having driven in Moreau's outpoſts, Suwarrow reſolved, on the 26th, to attack him in his entrenchments. For this purpoſe, while the ſhew of an attack was maintained along the whole line, a bridge was ſecretly thrown over among the rocks at the upper part of the river, where the French had thought ſuch an enterpriſe unlikely or impoſſible. A party of the combined army was thus enabled, on the following morning, after croſſing the river, to turn the French fortifications, and to attack their flank and rear, while the reſt of the army forced the paſſage of the river at different points. The French fought obſtinately, but were ſpeedily driven from all their poſitions, and compelled to retire to Pavia, leaving 6000 men on the field; while upwards of 5000 priſoners, including 4 generals, fell into the hands of the allies, together with 80 pieces of cannon.

359 And defeats him with great ſlaughter.

The advantage thus obtained over the French, in conſequence of the addreſs with which the Adda was croſſed, is ſaid to have gained for Suwarrow more eſtimation from his antagoniſts than they had originally been diſpoſed to grant to any military officer coming from Ruſſia, and who had never before had perſonal experience of the mode in which war is conducted in the ſouth of Europe. But this is probably affectation. The French had ſurely no cauſe to deſpiſe Ruſſian generals, ſince they could not but know that Laudohn was born in Ruſſia, that he had his military education there, and that he had riſen to a high rank in the army before he entered into the ſervice of the Empreſs Queen Maria Thereſa. Indeed it is evident, that while their orators were declaiming againſt Suwarrow and his Ruſſians as mercileſs barbarians, they were ſecretly trembling at his proweſs and reſources, which they could not but remember had more than once ſaved the armies of the Prince of Cobourg in the Turkiſh war.

Moreau now eſtabliſhed the wreck of the French army, amounting to about 12,000 men, upon the Po, between Aleſſandria and Valentia. On the 11th of May he compelled a body of Auſtrians to retire, though they had already paſſed the river, and took a great number of them priſoners. On the following day, 7000 Ruſſians croſſed the Po at Baſignano, and advanced on Pecetto. Moreau immediately fell upon them with his army. They maintained a long and deſperate conflict; but being at laſt thrown into confuſion, and refuſing to lay down their arms, about 2000 of them were drowned in recroſſing the river, and the French, with difficulty, took a ſmall number of them priſoners. But Suwarrow ſoon advanced, and terminated this active, but petty warfare, which was all that the French could now maintain. Moreau was under the neceſſity of retiring with his troops to occupy the Bochetta, and other paſſes which lead to the Genoeſe territory; and the combined army commenced vigorouſly, and at once, the ſiege of all the fortreſſes in the part of Italy which is now occupied. Peſchiera, Mantua, Ferrara, Tortona, Aleſſandria, and the citadels of Turin and Milan, were all attacked. The French were driven from the Engadine by Bellegarde; Maſſena, cloſely preſſed in Switzerland by the Archduke Charles, was compelled to retreat to the neighbourhood of Zurich, and almoſt all Piedmont had riſen in inſurrection againſt the French; ſo that in every quarter their affairs ſeemed deſperate. Few or no reinforcements arrived from the interior, and their generals were left to act upon the defenſive, and to detain the enemy at a diſtance from the frontiers of France as long as poſſible. One effort of offenſive war only remained, and, after ſome delay, it was made with much vigour.

Macdonald

French Revolution, 1799.

360 Macdonald and Moreau concert meaſures for attacking the allies.

Macdonald was ſtill with a conſiderable French army in the ſouthern parts of Italy, and occupied the territories of Rome and Naples. No attempt was made on the part of the combined powers to cut of his retreat; probably from the conviction that ſuch an enterpriſe could not be accompliſhed with ſucceſs in the mountainous countries of Tuſcany and Genoa, through which it would be in his power to paſs. Aware of this circumſtance, he was in no haſte to remove, though the combined army now occupied almoſt the whole territory between him and France. He gradually concentrated his forces, however, and drew near to the ſcene of action. His army amounted to 30,000 men; and he was ordered by the Directory to evacuate the new born republics of Rome and Naples, and to form a junction, if poſſible, with the army of Moreau. The preſent ſituation of the allies, however, tempted Macdonald to hazard an action by himſelf. Marſhal Suwarrow had extended his forces over Lombardy and part of Piedmont, in order to afford protection to the well diſpoſed inhabitants of theſe countries; and Macdonald and Moreau had concerted between them a plan for dividing their antagoniſts, and vanquiſhing them, as the French generals had often vanquiſhed their enemies in detail. It was only by Macdonald, however, that any important blow could be ſtruck; but it was neceſſary that Moreau ſhould draw upon himſelf a great part of the Auſtro-Ruſſian forces, that the remainder might be more completely expoſed to his colleague's attack. For this purpoſe he had recourſe to a ſtratagem.

361 Junction of the French and Spaniſh fleets.

Towards the end of April, the French fleet, amounting to 16 ſhips of the line, had ventured out of Breſt harbour. Ireland was ſuppoſed to be the place of its deſtination; and the Britiſh fleet was ſtationed in the ſituations moſt likely to prevent its arrival there. The French, however, intending to form a junction with the Spaniſh fleet, which was ſtill blockaded in the port of Cadiz, ſailed ſouthward. When they approached Cadiz, a ſtorm aroſe, which prevented any attempt on their part to enter the harbour, and any effort on the part of the Britiſh admiral, Lord Keith, to bring them to an engagement. On the 4th and 5th of May, therefore, they paſſed the Strait of Gibraltar, and ſteered for Toulon. Lord Keith kept his ſtation near Cadiz till the 9th of May, and then entered the Mediterranean in queſt of the French fleet. The Spaniards immediately put to ſea, and went into the Mediterranean alſo. The French fleet entered Toulon, and afterwards went out in queſt of the Spaniſh fleet. They ſailed towards Genoa, and afterwards to Carthagena, where they met their allies. The two fleets being now united once more, paſſed Gibraltar, and ſailed round to Breſt, where they arrived in ſafety, without being overtaken by the Britiſh.

362 Partial ſucceſſes of Macdonald.

Moreau, in the mean time, took advantage of the arrival of the French and Spaniſh ſquadrons in the vicinity of Genoa, to ſpread a report that they had brought him a powerful reinforcement of troops, in the hope of withdrawing from Macdonald the attention of Suwarrow. This laſt officer was himſelf at Turin. His advanced troops poſſeſſed the paſſes of Suſa, Pignerol, and the Col d'Aſſiette; while, at the lower extremity of the vaſt track of country over which his army was ſcattered, General Hohenzollern was poſted at Modena with a conſiderable force, and General Ott was at Reggio with 10,000 men. On the 12th of June, Macdonald began his operations. His advanced diviſions attacked Hohenzollern at Modena on that day, defeated him, and took 2000 of his men priſoners. The French, at the ſame time, attacked General Ott; and, after obliging him to retreat, they entered Parma on the 14th of June. On the 17th, General Ott was again attacked, and compelled to retire upon Caſtel St Giovanni. But here the progreſs of Macdonald was arreſted.

363 He is completely defeated by Suwarrow.

Suwarrow had been informed of his approach and alarming ſucceſſes; and with that preſence of mind, and that promptitude of energy, which ſo ſtrongly mark the whole of his conduct, he ſuddenly left Turin on the 15th of June, at the head of 20,000 men; and having marched ſeventeen leagues in eight-and-forty hours, came up with Macdonald's army on the banks of the Tidone. The Ruſſian Generals Roſenberg and Foerſter commanded the right and the centre; the left wing was commanded by the Auſtrian General Melas; the Ruſſian General Prince Procration commanded the advanced guard, and Prince Lichtenſtein the reſerve. A deſperate action now commenced, which, conteſted with equal obſtinacy on both ſides, was fought during three ſucceſſive days. At length victory, ſtill faithful to the ſtandard of Suwarrow, declared for the allies. The French, driven on the 1ſt day from the Tidone to the Trebbia, were there ultimately defeated on the 19th, after a carnage on both ſides, ſuch as ſome of the oldeſt officers in the army declared that they had never before ſeen. The Ruſſians and French repeatedly turned each others line, and were mutually repulſed. Suwarrow, who appeared in perſon wherever the fire was heavieſt, and his troops moſt cloſely preſſed, is ſaid to have had ſeven horſes killed under him, and to have ſtript himſelf to the ſhirt on the 19th, running on foot from rank to rank, to urge the troops forward by his preſence and example (H). With all theſe exertions of heroiſm, however, and greater have ſeldom been made, the iſſue of the conteſt continued doubtful, till the gallant Kray, in direct diſobedience to the pernicious orders of the Aulic Council at Vienna, arrived at the head of a large detachment from the army beſieging Mantua, and, on the 19th, decided the fate of the day.

The French fled during the night; and on the morning of the 20th, Suwarrow purſued them with his army in two columns. It ſeldom happens that German troops can overtake the French in a march. The Ruſſians now did ſo, however; and at Zena, the rear guard of the French, being ſurrounded, laid down their arms. The

(H) We had this information from an officer of high rank, now reſiding in Weimar, who was preſent in the action; and who added, that the Coſſacs, as ſoon as they ſaw their old commander in his *ſhirt*, ruſhed upon the enemy with an impetuoſity which nothing could withſtand. The ſtory is by no means incredible; for Suwarrow, who deſpiſes coſtume, is known to have fought repeatedly in his ſhirt againſt the Turks; and he would be as hot on the Trebbia as ever he was on the Danube.

French Revolution, 1799.

The reſt of the French army found ſafety in the paſſes of the Appennines and the Genoeſe territory, after having loſt on this occaſion, in killed, wounded, and priſoners, not leſs than 17,000 men.

Moreau, in the mean time, had attacked the Auſtrians under General Bellegarde in the vicinity of Alexandria. Though ſuperior to him in numbers, they were completely beaten; but Suwarrow having returned with infinite rapidity after his victory over Macdonald, the temporary advantage gained by Moreau became of no importance. Suwarrow complained loudly of the conduct of the Aulic Council on this occaſion; while they, in return, imputed their diſaſter under Bellegarde to his unſkilful diſtribution of the whole troops, which had expoſed an immenſe army to great danger from the enterpriſes of an handful of men. It is not our buſineſs to decide between them. The inſtructions of the Council to Kray not to co-operate with the commander in chief of the combined army, ſeem to us in the higheſt degree abſurd, if not treacherous; and we have heard a general officer, whoſe name, were we at liberty to give it, would do honour to theſe pages, ſay, that the diſtribution of the troops, of which that council complained, was the moſt maſterly thing that has been done during the war. Be this as it may, a diſtruſt and mutual miſunderſtanding thus commenced, or, at leaſt, made its firſt open appearance, which gave good reaſon to ſuſpect that little cordiality of co-operation would long exiſt between theſe allies. They continued, however, for ſome time to enjoy uninterrupted proſperity under the command of Suwarrow. The sieges of the different Italian fortreſſes were very cloſely preſſed. They all ſurrendered in ſucceſſion; and the period appeared faſt approaching when it would be in the power of the allied armies to enter the ancient territory of France.

364 Mutual complaints of Suwarrow and the Aulic Council.

If we turn our eyes to a different quarter, we ſhall find the French as much humbled at this time in Paleſtine by Britiſh valour, as they were in Italy by the united armies of Ruſſia and Auſtria. The hero of France, the conqueror of Italy, the boaſted legiſlator of Europe, after having defeated the Mamalukes, taken poſſeſſion of Alexandria and Cairo, and profeſſed himſelf a Mahometan in Egypt, led an army into Paleſtine with the avowed purpoſe, it has been ſaid, to take poſſeſſion of Jeruſalem, and by rebuilding the temple, and reſtoring the Jews, to give the lie to the prophecies of the Divine founder of the Chriſtian religion. At the head of a choſen band, exceeding 12,000 in number, and poſſeſſed of a ſtaff eminent for military ſkill and experience, he arrived at the ſmall town of Acre, ſituated on the ſea-coaſt, 28 miles ſouth of Tyre, and 37 north of Jeruſalem. To this town, which was wretchedly fortified, and defended only by a ſmall garriſon of Muſſelmans, he laid ſiege in form; and the governor would have ſurrendered unconditionally, had he not been, we ſay not *perſuaded*, but *decoyed*, by an Engliſh *naval* officer, to make a vigorous reſiſtance. We need not add, that the naval officer was Sir Sidney Smith, or that the beſieging general was Bonaparte.

365 Bonaparte's unſucceſsful attack of Acre.

The command of the garriſon being entruſted to Sir Sidney Smith, who was not to be bribed by French gold, or corrupted by French philoſophy, the hero who, by the aid of theſe allies, had ſo quickly routed armies, and conquered ſtates in Italy, was detained before the town of Acre *ſixty-nine* days; hough the number of the allies who defended that town exceeded not 2000 men! Foiled in *eleven* different attempts to carry it by aſſault, one of which was made during the truce which he himſelf had ſolicited to bury the dead, he was ultimately obliged to retreat, leaving eight of his generals, eighty-five of his officers, and *one half* of his army behind him. The ſuperiority of the Britiſh over the Corſican hero was, during this ſiege, more fully diſplayed in conduct than even in courage. The true magnanimity evinced by the former; his temperate replies to the audacious calumnies and atrocious falſehoods of his adverſary; and the moderation and humanity which characteriſed his diſpatches, and invariably marked his behaviour to thoſe whom the fortune of war ſubjected to his power—give additional luſtre to the brilliant victory which his valour, his energy, and his perſeverance, ſo eſſentially contributed to ſecure.

But while we pay a tribute of juſtice to the merits of our gallant countryman, we muſt not omit to notice the high deſerts of the brave, the loyal, the virtuous Philipeaux, his gallant comrade, the partner of his toils, and the partaker of his glory. The ſkill of this French officer as an engineer was moſt ſucceſsfully diſplayed in the defence of Acre; and, indeed, his exertions on that memorable occaſion ſo far ſurpaſſed his ſtrength, that he actually periſhed through fatigue.

366 His vaſt projects, had he ſucceeded.

The defeat of Bonaparte at Acre, which effectually ſtopped his deſtructive career, will be conſidered as important indeed, when it is known that his arts of intrigue had ſo far ſucceeded as to prevail on the numerous tribe of the Druſes to join his ſtandard with *ſixty thouſand* men immediately after the reduction of that town. Had this junction been effected, it was intended to proceed to Conſtantinople, and, after plundering the city, to lay it in aſhes! It is ſcarcely poſſible to calculate the dreadful conſequences of ſuch an event on the political ſtate of Europe. If ſervices are to be eſtimated in proportion to their effects, we know of none, during the preſent war, fertile as it has been in brilliant atchievements, that deſerves a higher reward than the defeat of Bonaparte at Acre.

During theſe reverſes abroad, France had begun to ſuffer much internal agitation, and the Directory found itſelf in a very difficult ſituation. The elections, as uſual, were unfavourable to them; and amidſt the contempt with which they now began to be regarded, it was no longer poſſible to ſecure a majority in the Councils, by unconſtitutionally annulling the elections of their political opponents. They demanded money, and were anſwered by reproaches, on account of their profuſion, and the rapacity of their agents. The royaliſts in the ſouth and the weſt began to form inſurrections. They were ſubdued with much difficulty, on account of the abſence of the troops. The people had totally loſt that enthuſiaſm which, in the earlier periods of the revolution, induced them to ſubmit to ſo many evils, and to make the moſt violent efforts without murmuring. They beheld the renewal of the war with regret, and were unwilling to aſſiſt by their exertions to reſtore power and ſplendour to the faction which had trampled upon their freedom.

Amidſt all theſe difficulties, an event occurred which, for a time, gave the Directory the hope of being once more able to rouſe the dormant energies of their countrymen. After the defeat of Jourdan, a detachment from

from the army of the Archduke Charles had occupied Rastadt, where the Congress still sat. On the 28th of April an order was sent by an Imperial officer to the French ministers, requiring them to quit Rastadt in 24 hours. They demanded a passport from Colonel Barbasey, who had sent the order; but this he could not grant, none having that power but the commander in chief. They declared themselves determined to depart without delay, although the evening approached. They were detained about an hour at the gate of the town, in consequence of general orders which had been received by the military to suffer none to pass. In consequence of an explanation, however, and of the interposition of superior officers, they were allowed to depart. The three ministers, Bonnier, Roberjot, and Jean Debry, were in carriages. The wife of Roberjot, and the wife and daughters of Jean Debry, were along with them; and they were attended by the ministers of the Cisalpine republic. When they had advanced to a very short distance from Rastadt, they were met by about 50 hussars of the regiment of Szeckler, who made the carriages to halt, and advancing to the first of them, containing Jean Debry, demanded his name. He told them his name, and added that he was a French minister returning to France. On receiving this answer, they immediately tore him from his carriage, wounded him in several places with their sabres, and cast him into a ditch, on the supposition that he was killed. They treated in the same manner the two other ambassadors, Bonnier and Roberjot, whom they murdered upon the spot. They offered no personal violence, however, to the rest of the company, who were allowed to return to Rastadt; but they robbed the carriages of whatever effects they contained; and the papers of the ambassadors were conveyed to the Austrian commander. After the departure of the soldiers, and the return of the carriages to Rastadt, Jean Debry wandered about the woods all night, and returned also to Rastadt on the following day. He claimed the papers belonging to the legation from the Austrian commander, but they were refused to be restored.

367 Assassination of the French envoys,

During the whole of the long period that the Congress had sat, Rastadt and its vicinity had been occupied by French troops, and it was only a few days since the Austrians had obtained possession of it. This event therefore cast, at least, a severe reproach upon the discipline of the Austrian army. It did more; it made every honest man regret, that troops, engaged in the support of a good cause, should think to promote that cause by the murder even of the greatest villains. The Archduke Charles made haste to disclaim all knowledge of it in a letter to Massena; but the French Directory, regarding it as a fortunate occurrence, from its tendency to rouse the resentment of the nation, addressed to the two Councils, on the 5th of May, a message, in which they ascribed it to a deliberate purpose on the part of the Austrian government to insult France by the assassination of her ambassadors. They thus converted the private act of a few desperate individuals into a measure of public policy; as if the death of those wretched miscreants could have been of consequence to the enemies of the *great* nation. The unpopularity of the Directory, however, and the obvious inutility of so gross a crime, prevented this accusation from obtaining much credit, or producing great effects upon the people. In a private letter which a friend of our's received at that period from the Continent, he was assured that the murder of the envoys "*fait plus de bruit que de sensation*;" and that the general opinion was, that the Directory itself knew more of the authors of that crime than the Archduke or the Austrian government.

368 Turned by the Directory to its own advantage.

369 Dissensions in France.

Upon the introduction of the new third of this year into the Councils, a violent opposition to the Directory commenced. Sieyes, who was ambassador at Berlin, and who had enjoyed, during the whole progress of the revolution, a very considerable influence over all the parties that had successively enjoyed the supreme authority, was elected into the Directory. At the first establishment of the constitution he had refused to occupy this station, and it excited much surprise when he readily accepted the office in the present calamitous state of the Republic. His admission into the Directory, however, did not reconcile the pulic or the two Councils to that body. A violent contest for power betwixt the Moderate and the Jacobin parties seemed to approach; but they soon came to a compromise. Treilhard was removed from the Directory, under the pretence that he had held an office in the state within less than a year previous to his nomination. Merlin and Reveillere were compelled to resign, to avoid an impeachment with which they were threatened; but Barras still contrived to retain his station. Moulins, Gohier, and Ducos, men little known, and by no means leaders of the contending parties, were appointed Directors. The power was understood to be divided, and that neither party greatly predominated. An attempt was made to revive public spirit, by encouraging anew the institution of clubs, which had been suppressed by the Directory. The violent Jacobins were the first to take advantage of this licence. They resumed their ancient style, their proposals for violent measures, and their practice of denouncing the members and the measures of government. But the Directory becoming alarmed by their intemperance, obtained leave from the Councils to suppress their meetings before they were able to interest the public in their favour.

370 Warlike efforts of the Directory.

Considerable efforts were now made by the French government to recruit their armies; but the deranged state of the finances, which the votes of the Councils could not immediately remedy, prevented the possibility of their gaining a superiority during the present campaign. The difficulty was also increased by the necessity of resisting immense armies in different quarters at the same time, France being assailed at once on the side of Holland, Switzerland, and Italy. Such, however, were the exertions of the Directory, that they seemed not destitute of the hope of being able speedily to assume, on the frontier, a formidable, and even menacing posture. In the beginning of August, their Italian army amounted to 45,000 men. The different bodies of troops of which it consisted had been drawn together, and concentrated nearly in the same positions which Bonaparte had occupied before his battles of Montenotte and Millesimo. The command of the whole was given to Joubert, a young man, who had been much distinguished under Bonaparte; and who, in the style of gasconade employed by that general, assured his government of victory, declaring, that he and Suwarrow should not both survive the first battle. In this boasting declaration he seems to have been in earnest;

371 Joubert assumes the command in Italy.

earneſt; for, on taking the command, he prevailed with Moreau to remain in the army as a volunteer till the firſt battle ſhould be fought. The allies had now taken Turin, Aleſſandria, Milan, Peſchiera, and Ferrara, with a rapidity which would lead one to ſuppoſe that
372 ſome new mode had been invented of materially abrid-
Succeſſes of the allies. ging the duration of ſieges. The ſtrong citadel of Turin opened its gates, to the aſtoniſhment of Europe, after a bombardment of only *three days;* the citadel of Aleſſandria ſurrendered to the Auſtrian General Bellegarde, on the 22d of July, after a ſiege of *ſeven days;* and the ſtill more important fortreſs of Mantua ſurrendered to the brave General Kray, on the 29th of the ſame month, after a ſiege of only *fourteen days.* The garriſon of Aleſſandria amounted to 2400 men; that of Mantua to 13,000. The former were detained priſoners of war, and the latter were allowed to return to France on their *parole;* a parole which the commanders of the allied armies could not reaſonably expect to be kept. This has given riſe to a ſuſpicion, that the fortreſs was voluntarily ſurrendered to the Auſtrians, in order that the Directory might recruit its armies with the garriſon.

The allies next began to beſiege Tortona, and Joubert reſolved to attempt its relief. He hoped to accompliſh this object, and to gain ſome advantage over their army, before General Kray could arrive to the aſſiſtance of Suwarrow with the troops that had been occupied in the ſiege of Mantua. On the 13th of Auguſt the French drove in the whole of the Auſtrian poſts, and took poſſeſſion of Novi. Here they encamped on a long and ſteep, but not high, ridge of hills, with their centre at Novi, their right towards Seravalle, and their left towards Baſaluzzo. On the 14th they remained quiet; and on the 15th they were attacked by Suwarrow, whoſe army was now reinforced by the arrival of General Kray from Mantua. The right wing of the allied army was commanded by Kray, its left by Melas, and its centre was occupied by the
373 Suwarrow's victory over Joubert, who is killed. Ruſſians, under Prince Pongrazion (Pracration) and Suwarrow in perſon, The attack began at 5 o'clock in the morning, and was continued during many hours. Soon after the commencement of the battle, while the French commander in chief, Joubert, was urging his troops forward to a charge with the bayonet, he received a muſquet ſhot in his body, and, falling from his horſe, immediately expired. Moreau inſtantly reſumed the command. After an obſtinate conteſt, the allied army gave way, and was compelled to fall back in all quarters. The attack, however, was repeatedly renewed, and much blood was ſhed. From the obſtinate manner in which they fought, the Ruſſians, in particular, ſuffered very ſeverely. They made three unſucceſsful efforts againſt the centre of the French army, and on each occaſion thoſe immediately engaged were rather deſtroyed than repulſed. The laſt attack along the whole line was made at three in the afternoon. The French remained unbroken; and the day muſt have terminated in the defeat of the allies, had not General Melas ſucceeded in turning the right flank of the French line. Their right wing was thus thrown into confuſion. Melas purſued his advantage till he obtained poſſeſſion of Novi, and the whole French army made a rapid retreat under the direction of Moreau.

According to the accounts given by the Auſtrians, the French loſt in this battle 4000 killed and an equal number taken priſoners. They acknowledged their own loſs in killed to be equal to that of the French, but the loſs ſuſtained by the Ruſſians was never publiſhed. The general reſult of the battle was the total ruin of the French affairs in this quarter. The allies retained their decided ſuperiority; and there was no enterpriſe which, on the preſent theatre of the war, they might not have ventured to undertake. The French renounced all hope of defending Genoa, and prepared to evacuate that city and its territory. The Directory expected an immediate invaſion of the ſouth of France, and addreſſed a proclamation to the people, urging them to act with firmneſs and energy amidſt the calamities with which the country was now menaced.
But theſe apprehenſions were unneceſſary. The court 374 Unaccountable conduct of the allies.
of Vienna had other objects in view that were leſs dangerous to their enemy. They neither invaded Genoa nor France, but quietly proceeded in the ſiege of Tortona. The vanquiſhed army was ſurpriſed to find itſelf unmoleſted after ſuch a defeat; and in a few days ventured to ſend back parties to inveſtigate the movements of the allies. The new Commander Championnet, who had ſucceeded Joubert, found to his no ſmall aſtoniſhment that they had rather retreated than advanced; and he immediately occupied the ſame poſitions which his army had held before the battle of Novi.

Inſtead of purſuing the advantages they had gained in Italy, the Aulic council, or council of war at Vienna, now perſuaded Suwarrow to leave that country with his Ruſſians, and to ſet out for Switzerland to drive the French from thence. In the early part of the campaign, the Archduke Charles had ſucceeded, after various attacks, in driving the French from the eaſtern part of Switzerland beyond Zurich, of which laſt city he retained poſſeſſion. The Directory, however, had ſent their new levies chiefly towards this quarter; ſo that in the middle of the month of Auguſt Maſſena's army amounted to 70,000 men. The Archduke was now ſo far from being able to purſue the advantages he had gained, that of late the French had reſumed the offenſive, and threatened to endanger his poſition. Their right wing under Lecourbe had even ſucceeded in taking poſſeſſion of Mount St Gothard, which is the great paſs that leads from the centre and eaſtern part of Switzerland into Italy. The cabinet of Vienna probably wiſhed to throw the ſevereſt duties of the
war upon their northern aſſociates. The veteran Suwar- 375 Suwarrow leaves Italy and marches to Switzerland.
row had never, during his long military career, ſuffered a ſingle defeat. His preſumption of ſucceſs was therefore high; and he perhaps felt himſelf not a little flattered by the requeſt to undertake an enterpriſe in which the Auſtrians had failed, though led by their moſt fortunate commander. It is indeed certain that he conſidered himſelf as called out of Italy too ſoon. Though confident of being properly ſupported, he agreed to proceed with his troops from Piedmont to Switzerland, where another Ruſſian army had lately arrived. Delays however were thrown in his way. Tortona did not fall quite ſo ſoon as was expected; and when he was ready to march, the Auſtrian commander in Italy refuſed to ſupply him with mules for the tranſport of his baggage. Unable to reply to the indignant expoſtulations of the Ruſſian hero, this man deſcended to a pitiful falſehood, by aſſuring him that he would find a

French Revolution, 1799.

sufficient number of mules at Bellinzone, where, when he arrived, not one was to be had. He had now no other resource but to dismount the cavalry, and employ their horses to drag along the baggage. Under all these difficulties, he arrived, by forced marches, on the confines of Switzerland, on the day appointed by him and the Archduke; but the Austrian cabinet had, in the mean time, taken a step which made all his exertions useless.

376 Is deserted, if not betrayed, by the Austrians.

Thinking it degrading to a Prince of the Imperial house, who had so long held the highest military rank, to serve under the Russian General, and not having the confidence to require the most experienced leader in Europe to receive the orders of a man so young as the Archduke, they sent that prince with his army to attack the French, who, in a small body, had entered into Swabia. He began accordingly to draw off his troops in the beginning of September, before Suwarrow was in readiness to leave Italy. The number which he took with him has been differently estimated, the lowest computation stating it at 48,000, and the highest at 60,000. The former is the most probable; since it is well known that 20,000 would have been fully adequate to the purpose for which he marched. The army which he left behind him is more perfectly ascertained: it consisted of 21,000 Russians, 18,900 Austrians, Bavarians, and other auxiliaries, forming a total of 39,900 men.

Upon what principle of military tactics the Aulic council could suppose that a skilful and intrepid commander like Massena, with a force nearly double that of the allies, would remain in a state of inactivity, it is not easy to conceive. He perceived at once the advantage which might be derived from this unaccountable movement of the Archduke. The French troops in Swabia were therefore ordered to advance rapidly, and to threaten the rear of the Archduke's army. As the repulse of these troops and the invasion of France towards Alsace, formed a part of the Austrian commander's plan of operations, he marched against them with his army. The French made as much resistance as the smallness of their force would permit. The Archduke however, gradually drove them towards the Rhine. The better to carry on their plan of deception, they made a serious stand in the neighbourhood of Manheim, and were defeated with the loss of 1800 men. The Austrians entered Manheim, and seemed ready to cross the Rhine in this quarter.

All this while Switzerland was left completely exposed to the enterprises of Massena. General Hotze, with the Austrians, occupied the right wing of the allied army there. The newly arrived Russian army was stationed in the centre at Zurich under the command of General Korsakof; and the left, consisting chiefly of Bavarians and other troops of the empire, was commanded by Nauendorf. Massena remained quiet till he learned that the Archduke had entered Manheim, and that Suwarrow, having taken Tortona, was on his march towards Switzerland by Mount St Gothard.

377 The allies defeated in Switzerland.

This last position was defended by Lecourbe; and Massena resolved, in the mean time, to anticipate the arrival of Suwarrow. On the 24th of September, having drawn the attention of the Russians to another quarter by a false attack, he suddenly crossed the Limmat, a river which divided the two armies near the convent of Far, which is three leagues distant from Zurich. A part of the French troops engaged the Austrians, while the greater part of the army marched against the Russians at Zurich. The Austrian General Hotze was killed in the commencement of the action. General Petrarch, who succeeded him in the command, contrived to avoid a total rout, and retired during the night with the loss of about 4000 men. The contest with the Russians was singularly obstinate. In a mountainous country, to which they were strangers, and contending against the most skilful military leaders that the south of Europe had been able to produce, they laboured under every disadvantage. They could not be put to flight however; and even when different divisions of them were surrounded, they refused to lay down their arms, and were slaughtered upon the spot. By the retreat of the Austrians on the evening of the 25th, they found themselves on the 26th nearly surrounded in Zurich. They now began to retreat also; and we are only surprised at the ability of the Russian General in effecting his retreat in such good order, and with such little loss; for if the official accounts deserve credit, his loss in killed, wounded, and taken, did not exceed 3000 men. He was obliged, however, to abandon his baggage and cannon to the enemy. 378

Suwarrow's march.

During these operations, Suwarrow was advancing on the side of Italy with an army rated, in some accounts, at 18,000, in others at only 15,000; and forcing the French from their strong positions on Mount St Gothard, descended, on the very day on which Massena made his general attack, into the valley of Ursern; and driving Lecourbe before him, with considerable slaughter, advanced as far as Altorf. He even penetrated on the next day into the canton of Glaris, and took 1000 of the French prisoners; while the Russian General Rosemberg was equally successful in the canton of Schwitz, where General Auffenberg had effected a junction with him; and General Linken defeated and took another corps of French, consisting of 1300 men.

379 His admirable conduct.

Massena, however, now turned upon the Field-marshal with the greater part of his army; and, by hemming him in on all sides, expected to have made him, and the Grand Duke Constantine, prisoners. Suwarrow, however, defended himself against every attack with unexampled vigour and address. A single pass among the mountains was all that remained unoccupied by the French. He discovered this circumstance, and escaped, though closely pursued. He lost his cannon, baggage, and provisions, among the dreadful mountains and precipices with which that country abounds. He made his way, however, eastward through the Grison country, and at length arrived at Ceire with about 6000 men in great distress.

380 His indignation at the court of Vienna.

Nothing could exceed the indignation of this old warrior when he discovered the manner in which affairs had been conducted, the hazardous state in which the Russians had been abandoned by the Archduke, and the consequent ruin which they had encountered. He considered himself and his countrymen as treacherously exposed to destruction; he loudly complained of the Commander of the allied forces in Switzerland; publicly taxed the Council of Vienna with selfishness and injustice; and refused all farther co-operation with the Austrian army. He sent an account of the whole transaction

French Revolution, 1799. action to St Peterſburgh in a letter, of which the compoſition would do honour to the fineſt writer of the age, and withdrew with his troops to the neighbourhood of Augſburg to wait for farther orders.

380 Invaſion of Holland

In the mean time, Great Britain prepared to invade Holland with an army of 40,000 men, conſiſting of Britiſh troops and Ruſſian auxiliaries. The firſt diviſion under General Sir Ralph Abercromby, failed in the month of Auguſt, under the protection of a fleet commanded by Admiral Lord Duncan. Bad weather prevented a landing from being attempted till the 27th. On the morning of that day the troops landed without oppoſition upon the ſhore of Helder Point in north Holland, at the entrance to the Zuyder Sea. They had not been expected in this quarter, and the troops in the neighbourhood were conſequently few. The Britiſh, however, had no ſooner begun to move forward, than they were attacked by a conſiderable body of infantry, cavalry, and artillery, who had been haſtily aſſembled from the neareſt towns. The Dutch troops maintained the conteſt with much obſtinacy; but they were gradually fatigued by the ſteady oppoſition they encountered, and retired to the diſtance of two leagues. In the night they evacuated the fort of Helder, of which the Britiſh took poſſeſſion on the morning of the 28th. A detachment from the Britiſh fleet, commanded by Vice Admiral Mitchell, now entered the Zuyder Sea

381 Capture of the Dutch fleet.

by the ſtrait of the Texel, to attack the Dutch fleet under Admiral Story. This laſt officer, inſtead of retiring for ſafety to any of the ports, or to the ſhallow water with which that ſea abounds, ſurrendered the whole fleet on the 30th of Auguſt without firing a gun, under pretence that his ſeamen were mutinous, and would not fight.

Had the expedition terminated here, it might have been regarded as extremely fortunate, and as eſtabliſhing the power of the Britiſh navy without a rival. But it was reſolved to follow up this firſt ſucceſs by an effort on land to reſtore the authority of the Stadtholder, and the ancient government of the United Provinces. Many circumſtances were hoſtile to this enterpriſe. The whole army had not been ſent at once from Britain. As no more than the firſt diviſion had arrived, the troops could only reſt upon the ground they had gained till reinforcements ſhould be ſent. The terror ariſing from the firſt appearance of an invading army was thus allowed to paſs away, the enemies of the preſent Dutch government were diſcouraged, and leiſure was afforded to adopt effectual meaſures of defence. The place where the landing was effected was well choſen for an attack upon the Dutch fleet; but for an invaſion, with a view to the reſtoration of the Stadtholder, it was the worſt that could have been ſelected. North Holland, at the extremity of which it was made, is a narrow peninſula, everywhere interſected by canals and ditches, of about 40 miles in length. Here the invaders might be detained, and even ſucceſsfully reſiſted, by a force greatly inferior to their own. This alſo is the quarter of the country the moſt unfavourable to the cauſe of the Stadtholder. In Zealand, where his eſtates are ſituated, and in Rotterdam, which is full of Scotchmen and of families of Scottiſh extraction, his friends are numerous and powerful; but in Amſterdam, and in North Holland, which is under its influence, his enemies abound, and the reſiſtance to his power has been very great during every period of the Dutch hiſtory. When to all this it is added, that the rainy ſeaſon was approaching, and that a winter campaign in Holland is almoſt impoſſible, it will not appear ſurpriſing that this expedition was attended with little ultimate ſucceſs. It is ſaid that, amidſt the preſſure of the many difficulties which ſurrounded them, the French Directory heſitated much about undertaking the defence of Holland; but the place, and the time of landing the invading army, at once brought them to a determination. General Brune was ſent thither, with whatever troops could be haſtily collected, to ſupport the Dutch General Daendels. 382

Progreſs of the invaders.

General Abercromby, in the mean time, remained upon the defenſive at Schager Brug, waiting for reinforcements. His inactivity encouraged the enemy on the 10th of September to venture an attack upon his poſition. They advanced in three columns, two of which conſiſted of Dutch and one of French troops. They were repulſed, however, in all quarters, and retired to Alkmaer. On the 13th the Duke of York arrived with additional troops, and aſſumed the chief command. The Ruſſian auxiliaries having alſo arrived, offenſive operations were immediately reſolved upon. On the 19th the army advanced. General Abercromby commanded the left, which proceeded along the ſhore of the Zuyder Sea againſt Hoorne. The centre columns were commanded by Generals Dundas and Pultney; and the right wing, conſiſting of Ruſſians, was commanded by their own General D'Herman. In conſequence of ſome ſtrange miſunderſtanding, the Ruſſians advanced to the attack ſoon after three o'clock in the morning, which was ſome hours previous to the movement of the reſt of the army. They were ſucceſsful in their firſt efforts, and obtained poſſeſſion of the village of Bergen; but preſſing eagerly forward, and being unſupported by the other columns, they were nearly ſurrounded. Their commander was taken priſoner; and though the Britiſh came in time to protect their retreat, they loſt at leaſt 3000 men. This failure on the right obliged the Britiſh Commander in Chief to recal his troops from the whole advanced poſitions they had gained, though General Abercromby had actually taken Hoorne with its garriſon, and although General Pultney's column had carried by aſſault the principal poſition of the Dutch army called *Ourds Carſpel*.

The ſeverity of the weather prevented another attack till the 2d of October, when, after an engagement that laſted from ſix in the morning till the ſame hour in the evening, the Britiſh army ſucceeded in driving the united Dutch and French troops from Alkmaer and the villages in its neighbourhood. The conteſt was chiefly conducted among the ſand hills in the vicinity of the ocean; and the battle was maintained with ſuch obſtinacy, that the fatigue of the troops, together with the difficult nature of the country, prevented the Britiſh from gaining any great advantage in the purſuit. The retreating army immediately occupied a new poſition between Baverwyck and Wyck op-zee. The Duke of York once more attacked them on the 6th; and after an obſtinate and bloody engagement, which was maintained till night, he remained in poſſeſſion of the field of battle. But this was the laſt ſucceſs of the invaders. Finding himſelf unable to make farther progreſs, in conſequence of the increaſing numbers of the enemy, the impracticable nature of the country, and the badneſs of

383 Stopped by the enemy and the inclemency of the weather.

French Revolution, 1799.

of the weather, which, during the whole of this year, was unuſually ſevere, the Duke of York retired to Schager Brug, and there waited for orders from England to return home. He was, in the mean time, cloſely preſſed by the United Dutch and French forces, ſo that his embarkation muſt have been attended with much hazard. He therefore entered into a convention with the French and Dutch generals; by which it was agreed, that they ſhould no farther moleſt him in his retreat, and that, in return, he ſhould not injure the country by breaking down any of the dykes which protect it againſt the ſea, and that Great Britain ſhould reſtore to France and Holland 8000 priſoners of war, taken previous to the preſent campaign.

In conſequence of theſe events, the affairs of France now began to aſſume a leſs unfavourable aſpect They were indeed driven to the extremities of Italy, Championet was defeated in every effort which he there made againſt the Auſtrians during the reſt of the year, and Ancona, which was the laſt place of any ſtrength poſſeſſed by the French, alſo ſurrendered on the 13th of November to General Frolich; but they retained the Genoeſe territory, and Switzerland and Holland continued under their power. The new coalition againſt them ſeemed once more ready to diſſolve. From the commencement of the French Revolution, a ſpirit of ſelfiſhneſs had mingled with all the efforts made by the continental powers of Europe againſt it, and had rendered them fruitleſs. To prevent the aggrandiſement of Auſtria, Pruſſia had early withdrawn, and ſtill ſtood aloof. Spain and Holland were retained under the influence of France by the efforts of her arms, and by the univerſal diffuſion of her wild principles among the people. Even the Britiſh cabinet, which of all the European powers has remained moſt true to the original purpoſe of the war, ſometimes forgot that object. Thus, when invading Holland, the Dutch were informed, by a proclamation, that their ancient government was to be reſtored; but no offer was made to reſtore their diſtant poſſeſſions. Of all the coaleſced powers, however, Auſtria purſued her ſeparate intereſts with the leaſt diſguiſe. With much facility ſhe relinquiſhed the Netherlands, and ſuffered the principal bulwarks of Germany, Mentz, and Ehrenbreitſtein, to fall into the hands of the French, upon obtaining in exchange the Venetian territories, which Bonaparte had conquered, and thought himſelf authoriſed to ſell. During the preſent campaign, the whole conqueſts made by the united efforts of the Auſtrian and Ruſſian forces were ſeized by Auſtria in her own name, and none of the princes of Italy obtained leave to reſume the government of their own territories. This conduct on the part of the allies gave every advantage to the French. They broke off the negociations at Liſle, under the pretence of defending the Dutch and Spaniſh ſettlements which the Britiſh government refuſed to relinquiſh. They found it eaſy to alarm the King of Pruſſia, by diſplaying the unbounded ambition of the houſe of Auſtria; and the Emperor of Ruſſia, having publicly declared to the members of the German empire, that the purpoſe for which he had taken up arms was not to diſmember France, but to reſtore peace to Europe, became jealous of the Court of Vienna, when he ſaw it purſue a conduct ſo very different. This jealouſy was encreaſed by the misfortunes of the Ruſſian troops; and all circumſtances ſeemed now to promiſe that the new coalition would ſpeedily be deſerted by its northern auxiliary.

384 Coalition againſt France ready to be diſſolved.

While affairs were in this ſtate, an event occurred which exhibited the French Revolution under a new aſpect. When Bonaparte found himſelf compelled to retreat baffled and diſgraced, from the ruins of Acre, he learned that a Turkiſh army was ready to invade Egypt by ſea. He returned, therefore, with his uſual celerity, by way of Suez, acroſs the deſart of Arabia Petrea, which divides Syria from that country, and was in the neighbourhood of the Pyramids on the 11th of July, when an army of 18,000 Turks landed from 100 ſhips at Aboukir. They took this fort by aſſault, and gave no quarter to the French garriſon of 500 men that it contained. On the 15th, Bonaparte began to march down the country againſt them. On the 25th he came in ſight of them, at ſix o'clock in the morning.

385 Bonaparte vanquiſhes the Turks in Egypt.

It is not wonderful that thoſe barbarians afforded him an advantage which had ſo often been preſented by the armies of Auſtria. They had divided their force into two parts, which were encamped on the oppoſite ſides of a beautiful plane. He had now formed a conſiderable body of cavalry, by obtaining for his men fleet horſes from Arabia. Theſe advanced rapidly into the centre of the Turkiſh army, and cut off the communication between its different parts. His infantry then attacked the right, which was the weakeſt diviſion of the Turks. They being ſpeedily panic ſtruck, attempted to fly to their ſhips, and every man was drowned in the ſea. The left diviſion of the Turks was next attacked. It made a more obſtinate reſiſtance, but was ſoon alſo put to flight. Some caſt themſelves into the ſea, and periſhed in attempting to reach the boats of their fleet; the reſt took refuge in the fort of Aboukir. The news of this battle reached France towards the end of September, and revived the memory of Bonaparte's victories, contraſted with the reverſes which the Republican armies had lately experienced. On the 10th of October a diſpatch was received from him by the Directory, and read to the Councils, giving an account of the capture of the fort of Aboukir, with the whole remains of the Turkiſh army. On the 14th of the ſame month a meſſage from the Directory announced, to the aſtoniſhment of all men, that Bonaparte, along with his principal officers, had juſt arrived in France, and that they left the army in Egypt in a proſperous ſtate. This laſt part of the meſſage was ſoon afterwards proved, by the intercepted letters of Kleber, and the other generals left behind, to be a ſcandalous falſehood. In one of theſe letters, Pouſſielgue ſays, "Every victory carries off ſome of our beſt troops, and their loſs cannot be repaired. A defeat would annihilate us all; and however brave the army may be, it cannot long avert that fatal event."

386 Arrives with his principal officers in France,

Bonaparte, however, was received at Paris with diſtinction, though nobody could tell why he had deſerted his army and come thither. The parties in the government were equally balanced; and both the Jacobins, and what were called the *Moderates*, ſolicited his aſſiſtance The Jacobins ſtill poſſeſſed a majority in the Council of Five Hundred; but in the other Council their antagoniſts were ſuperior. The Director Sieyes was underſtood to be of the party of the Moderates; and the Jacobins had of late unſucceſsfully attempted to to remove him from his office, under the pretence that the interval appointed by the constitution had not elapsed between his going out of the Council of Five Hundred and his election to the office of director. Neither party was satisfied with the existing authorities; but none of the usual indications of approaching hostilities appeared. The Jacobins were far from suspecting that Sieyes had a plot ripe for execution, which was to overwhelm them in an instant. They were even in some measure laid asleep by an artful scene of festivity, in which the whole members of the Councils were induced to engage, on the 6th of November, under pretence of doing honour to the arrival of Bonaparte. On the morning of the 9th, one of the committees of the Council of Ancients, called the committee of Inspectors of the Hall, presented a report; in which they asserted that the country was in danger, and proposed to adjourn the sitting of the legislature to St Cloud, a village about six miles from Paris. We have already mentioned, that the constitution entrusted to the Council of Ancients the power of fixing the residence of the legislative bodies, and that this Council could in no other case assume the initiative, or propose any law; their powers of legislation being otherwise limited to the unconditional approbation or disapprobation of the decrees passed by the Council of Five Hundred. The Council of Ancients now suddenly decreed, that both Councils should meet next day at St Cloud. As the Council of Five Hundred had no constitutional right to dispute the authority of this decree, and as the ruling party in it was completely taken by surprise, its members silently submitted, and both Councils assembled on the 10th of November at the place appointed.

387 And seizes the reins of government.

The Council of Five Hundred exhibited a scene of much agitation. They received a letter from Legarde, secretary to the Directory, stating, that four of its members had sent resignations of their offices, and that the fifth (Barras) was in custody by order of General Bonaparte, who had been appointed commander of their guard by the Council of Ancients. While the Council were deliberating, Bonaparte entered the hall, attended by about twenty officers and grenadiers. He advanced towards the chair, where his brother Lucien Bonaparte sat as president. Great confusion ensued; he was called a Cromwell, a Cæsar, an usurper. The members began to press upon him, and his countryman Arena attempted to stab him with a dagger. He was rescued by his military escort. Lucien Bonaparte then left the chair, and cast aside the badge of office which he wore as a member of the Council. The confusion did not diminish; but in a short time a party of armed men rushed into the hall, and carried off Lucien Bonaparte. A tumultuous debate now began; in which it was proposed that Bonaparte should be declared an outlaw. The debate was soon terminated, however. The doors of the hall were once more burst open. Military music was heard; and a body of troops proceeding into the hall in full array, the members were compelled to disperse. The Council of Ancients, in the mean time, setting aside the constitution, passed a variety of decrees. They abolished the Directory, and appointed in its stead an Executive Commission; to consist of Bonaparte, Sieyes, and Roger Ducos, under the appellation of Consuls. They adjourned the sittings of the legislative bodies till the 20th of February, and appointed two committees, consisting of twenty-one members, selected from each of the two councils, to act as legislators in the mean time. They also expelled a great number of members from their seats in the councils.

Most of the members of the Council of Five Hundred returned to Paris, after having been driven from their hall by the military; but a part of them remained at St Cloud, and, on the evening of the same day, confirmed all the decrees of the Council of Ancients. The new government entered upon its functions at Paris on the following day. That city remained tranquil, and the public funds even rose upon the occasion. On the 17th of November the consuls decreed the transportation of a great number of the leading Jacobins and zealous republicans to Guiana, and ordered many others to be imprisoned; but these decrees were speedily recalled, and affairs went on as quietly as if nothing unusual had occurred.

388 Motions of Tippoo Sultan in India.

While Bonaparte was thus obtaining boundless personal aggrandisement in Europe, the African expedition in which he had been engaged was utterly unsuccessful in all its objects. The circumstances which led to it, so far as concerned foreign nations, now came to light, and were shortly these: Tippoo Sultan, the son and successor of the celebrated Hyder Ally, and sovereign of the Mysore country, which forms a part of the peninsula of India, had been compelled to conclude a treaty of peace in the year 1792 with the British governor general, Lord Cornwallis, under the walls of Seringapatam his capital. By this treaty he resigned to the invaders a part of his territory, and agreed to pay a large sum of money. He was, moreover, under the humiliating necessity of consenting that two of his sons should be delivered as hostages, to remain with the British till the pecuniary payments could be completed.

A war thus concluded could not become the foundation of much cordial amity between the parties. Tippoo had inherited from his father a deep sentiment of hostility against the growing power of Britain in India. Though he submitted on the occasion now mentioned to the necessity of his circumstances, yet he only waited a more fortunate opportunity to endeavour to recover what he had lost; and even, if possible, to accomplish the favourite object of all his enterprises, the complete expulsion of the British from India. At a former period, almost the whole of the native princes of this vast continent had entered into a combination against the power of Britain; but their designs had been defeated by the talents and exertions of Warren Hastings, Esq. The ascendency of the British government in this quarter was now so great, that no such combination could again be formed, and Tippoo felt that its power could only be shaken by the aid of an European army. France was the only country from which he could hope to obtain an adequate force. By the events of the revolution, however, and by the pressure of the war at home, the rulers of France had been prevented from attending to distant views and interests. Their settlements in India had been seized by the British, and they had ceased to retain any possessions beyond the Cape of Good Hope, excepting the islands of Mauritius and Bourbon.

389 He renews his intercourse with the French.

In the year 1797, Tippoo resolved to endeavour to renew his intercourse with the French by means of these islands. One Repaud, who had once been a lieutenant in the French navy, and had resided for some time at Seringapatam, French Revolution, 1799. gapatam, had misled Tippoo into a belief that the French had a great force at the Mauritius, which could immediately be sent to his aid in case of a war. He therefore fitted out a ship, of which he gave the command to Ripaud, and sent two persons in it as his ministers, with powers to negociate with the French leaders at the Mauritius. But, at the same time, to avoid exciting the suspicions of the British government in his neighbourhood, he directed his messengers to assume the character of merchants, to act in that capacity in public, and to conduct their political negociations with secrecy. They arrived at the Mauritius towards the close of the year 1797, and opened their proposals to Malartic the governor, for an alliance between Tippoo and the French nation, with the view of obtaining the aid of an European army. They were received with great joy, and vessels were instantly dispatched to France to communicate their proposals to the Directory.

In the mean time, Malartic the governor of the Mauritius, from folly, from treachery, or from a desire to involve Tippoo, at all hazards, in a quarrel with the British, took a step which ultimately was in a great measure the means of defeating the plans, and accom-

390 His conduct watched by the British. plishing the ruin of that prince. On the 30th of January 1798, he published and distributed a proclamation, in which he recited the whole private proposals of Tippoo, and invited all French citizens to enlist in his service. Copies of this proclamation were speedily conveyed by different vessels, touching at the Mauritius, to the continent of India, to Britain, and to all quarters of the world. Accordingly, as early as the 18th of June 1798, the secret committee of the Court of Directors of the East India Company in London wrote to their governor general in India, requiring him, in consequence of this proclamation, to watch the conduct of Tippoo, and even to engage in hostilities, if the measure should appear necessary. Before that period, however, the government in India had been alarmed, by the same means, and was making preparations for war. This, however, was no easy matter. It is the nature of European power, in these countries, gradually to decline. The nature of the climate, the view of returning home, and the distance from the seat of government, speedily introduce a relaxation of the efforts and the vigilance by which dominion was originally acquired. The troops require to be continually renewed by levies from the parent country; and if this precaution is neglected for a very short time, or negligently attended to, they become unable to protect the extensive territories such as Britain now possessed in India. When Lord Mornington, the governor-general, enquired into the state of the British army at Madras, and whether he might hazard an offensive war against Tippoo; he was informed that three, if not six months would be necessary to assemble the scattered divisions of the army, and to prepare them to defend their own territory. It was added, that such was the feeble state of the British forces in that quarter, that it might even be unsafe to excite suspicion in Tippoo by military preparations, as he might, in that case, ruin them by a sudden attack. Lord Mornington, however, resolved to encounter every hazard, and ordered immediate and active preparations in every quarter.

In the mean while, Tippoo did not trust for success to the aid of France alone. He endeavoured to bring an attack upon the British and their allies, or subjects in India, from the north west, by inviting Zemaun Shah to invade the country. This prince is at the head of a formidable kingdom, made up of provinces torn from both Persia and India. It was founded about sixty years ago by Ahmed Khaun Abdalla, an Affghan chief, who followed Nadir Shah on his invasion of India in 1739. He himself afterwards invaded India no less than seven times; and, in particular, he overthrew, with dreadful slaughter, the united forces of the Mahratta empire, in the year 1761, on the plains of Panipat. He was succeeded, in 1773, by his son Timmur Shah, who died, and was succeeded by his own son, the present prince. The dominions of Zemaun Shah extend from the left bank of the river Indus, on the sea-coast, as far northward as the latitude of Cashmeer; and from east to west they are 650 English miles in length, comprehending the provinces of Cabal, Candahar, Peishere, Ghizni, Gaur, Sigistan, and Korasun. He usually keeps in pay an army of 150,000 horse, besides infantry to garrison his fortresses. In expectation of direct aid from France, by Bonaparte's expedition to Egypt, and of an important diversion to be made by Zemaun Shah, Tippoo endeavoured to remain quiet, and to temporise with the British.

Since the first victories of Lawrence and of Clive, the native princes of India have been eager to introduce the European art of war among their subjects. For this purpose they retain European adventurers to command and discipline a part of their troops, and even endeavour to form a guard for their persons of European soldiers. The Nizam, a prince in alliance with the British, though in a great measure under their influence, had long retained around his person a considerable body of French, and of troops under their management. These, under the command of one Perou, now possessed great influence at Hydrabad, the capital of the Nizam. It was of much importance that these should be removed out of the way, to enable the British to obtain the aid of this prince as an ally in the approaching contest with Tippoo. Lord Mornington procured this object to be accomplished with so much success, that, on the 22d of October 1798, the French corps under Perou was surrounded and disarmed without bloodshed, and a British force was substituted as a guard to the Nizam in its stead. The military preparations being in a considerable state of forwardness, Lord Mornington next warned Tippoo Sultan, in a letter dated the 8th of November 1798, of his having a knowledge of his hostile designs and connection with the French. He also proposed to send an ambassador to treat about the means of restoring a good understanding between the states. Tippoo avoided returning an answer till the 18th of December, and then merely denied the accusation, and refused to receive the ambassador. On the 9th of January 1799, the British governor again urged in writing that the ambassador should be received. No answer was returned for a month; and, in the mean time, an army of 5000 men having arrived from England, orders were issued to General Harris to advance at the head of the Madras army against the kingdom of Mysore. Tippoo now offered to receive the ambassador, providing he came without an attendance; but this concession was not accounted sufficient, and the army advanced. An army from

391 General Harris advances against him.

French Revolution, 1799.

from Bombay was, at the fame inftant, advancing on the oppofite fide of his dominions. A part of Tippoo's forces encountered this army and were defeated; and within a few days thereafter, on the 27th of March, the reft of his army was defeated by General Harris. When an European army in India is tolerably numerous, the detail of its military operations againft the natives is by no means interefting; for the inhabitants of thefe enfeebling and fertile regions can never be made, by any kind or degree of difcipline, to poffefs that moral energy which enables men to encounter danger with coolnefs and felf-command. They can rufh on death under the influence of rage or defpair, but they cannot meet the hazard of it with calmnefs and recollection. It is fufficient to remark that, on the 7th of April, General Harris fat down before Seringapatam. On the 9th Tippoo fent a letter to this officer, alleging his own adherence to treaties, and enquiring into the caufe of the war. He was anfwered by a reference to Lord Mornington's letters. On the 20th he made another attempt to negociate, by writing to General Harris, requefting him to nominate commiffioners to treat of a peace. In anfwer to this propofal, certain articles were fent to him as the only conditions that would be granted. By thefe he was required to furrender half his dominions, to pay a large fum of money, to admit refident ambaffadors from the Britifh and their allies, to renounce all connection with the French, and to give hoftages for the fulfilment of thefe ftipulations.

On the 28th of April Tippoo again wrote to General Harris, requefting leave to treat by ambaffadors; but his propofal was refufed, upon the footing that he was already in poffeffion of the only terms of peace which would be granted. Could Seringapatam have held out for little more than a fortnight longer, the invading army muft have retreated. The rainy feafon was about to commence; and, by fome ftrange effect of negligence or treachery, provifions were fo deficient in the camp, that it was only by reducing the troops to

392 And takes Seringapatam.

half allowance that they could be made to laft till the 15th of May. On the 30th of April, the befiegers began to batter the walls of Seringapatam; and a breach being made, the city was taken by affault on the 4th of May. One o'clock afternoon had been chofen for this purpofe, as the hotteft hour of the day, and confequently the time when it would be leaft expected. Tippoo was in his palace; but on being informed of the attack, he haftened to the breach, and fell undiftinguifhed in the conflict. His treafures, and the plunder of the city, which was immenfe, went to enrich the conquering army, after deducting a fhare for the Britifh government and Eaft India Company. His kingdom immediately fubmitted. The part of it which formed the ancient kingdom of Myfore was beftowed upon a defcendant of the former race of its kings, whom Hyder Ally had deprived of the fovereignty; the additional territories that had been conquered by Hyder Ally were divided between the Britifh and their allies, the Nizam and the Mahrattas. The family of Tippoo were either taken in the capital, or voluntarily furrendered themfelves to the conquerors. They were removed from that part of the country, and allowed a confiderable penfion.

In the mean time, Zemaun Shah had actually invaded India from the north-weft. He advanced to the vicinity of Delhi, fpreading terror and defolation wherever he came. Had the French army in Egypt been able to detach a body of 15,000 men to the affiftance of Tippoo, while all India was in the ftate of alarm naturally produced by the approach of this northern invafion, it is extremely probable that the Britifh forces might fpeedily have found themfelves deferted by every ally, and funk under an unequal conteft. But the actual refult was very different. Satisfied with the plunder he had obtained, Zemaun Shah foon withdrew; and the French army being detained in Egypt by the war with the Turks, and by the want of veffels at Suez wherewith to reach India, Tippoo was left to contend, unaffifted, againft the whole power of Britain, and of its allies in the eaft. By the conqueft and divifion of his territory, the Britifh power was left without a rival in that quarter of the world, and raifed to fuch a ftate of impofing fuperiority, that if affairs are only preferved in their prefent fituation, by periodical fupplies of European troops, no native prince, or even combination of princes, can henceforth bring it into danger. Thus, notwithftanding the vaft military efforts made by the people of France during this revolutionary war, yet all foreigners who trufted to their aid were ruined by placing confidence in them. In Italy, Germany, Switzerland, and Holland, the rapacity of the commiffaries of the French government foon rendered odious and intolerable the prefence of thofe armies whofe arrival had been eagerly defired. In Ireland and in India, the promife and the hope of affiftance which they were never able to beftow, only ferved to produce premature hoftility, and to increafe and eftablifh the power of the Britifh government.

393 Immenfe power of Britain in India.

But to return to the domeftic hiftory of France, which has now become only an hiftory of the ufurpation of Bonaparte.

394 New conftitution of France.

In the middle of the month of December, the Confuls, with their legiflative committees, produced to the public their plan of a new conftitution, which they prefented to the primary affemblies, and which is faid to have been accepted by them without oppofition, like all the former conftitutions. It is a very fingular production, and neither admits of reprefentative government, nor indeed of any other form of political freedom. Eighty men, who elect their own fucceffors, poffefs, under the appellation of a *Confervative Senate*, the power of nominating the whole legiflators and executive rulers of the ftate; but cannot themfelves hold any office in either of thefe departments. The fovereignty is concentrated in one man, who, under the title of *Chief Conful*, holds his power for ten years, and may be re-elected. The whole executive authority is entrufted to him, and he enjoys the exclufive privilege of propofing new laws. He is affifted by two other confuls, who join at his deliberations, but cannot controul his will. The legiflative power is entrufted to two affemblies: the one, confifting of 100 members, called a *Tribunate*; and the other, of a *Senate*, of 300 members. When a law is propofed by the Chief Conful, the Tribunate may debate about it, but have no vote in its enactment. The Senate votes for or againft its enactment, but cannot debate about it. Neither the Confuls, nor the members of the legiflative bodies, nor of the confervative fenate, are refponfible for their conduct. The minifters of ftate, however, who are appointed by the

French Revolution, 1799.

the Chief Consul, are responsible for the measures they adopt.

The people in the primary assemblies elect one tenth of their number as candidates for inferior offices; persons thus chosen, elect one-tenth of themselves as candidates for higher offices; and these again elect a tenth of themselves as candidates for all the highest offices of the state. Out of this last tenth the Conservative Senate must nominate the consuls, legislators, and members of their own body. But this last regulation is to have no effect till the ninth year of the republic. In the mean time, the same committees that framed the constitution, appointed also the whole persons who were to exercise the government. Bonaparte was appointed Chief Consul, and Cambaceres and Lebrun second and third Consuls. Sieyes, with his usual caution, avoided taking any active share in the management of public affairs, and was appointed, or appointed himself, a member of his own Conservative Senate; the whole being regarded as produced by him. As a gratuity for his services, the Chief Consul and his legislators presented to him an estate belonging to the nation, called *Crosne*, in the department of Seine and Oisne.

395 Absolute power of Bonaparte.

Thus, after all their sanguinary struggles for freedom, did the son of a Corsican drive from their stations the representatives of the French nation, and assume quiet possession of the government of that country, with a power more absolute than ever belonged to its ancient monarchs. The established privileges of the clergy, the nobles, and the parliaments, always restrained, in some degree, the despotism of the kings of France; these being now destroyed, the will of Bonaparte could meet with no controul.

396 Proposals for peace made by the Consul,

One of the first measures of his government was to transmit to the allied powers, then at war with France, proposals for negociating peace; but in these proposals it was easy to discover that a *general* peace was not the object of his wishes. He was, indeed, under the necessity of making some kind of pacific overtures, that he might keep the promise by which he had bribed the people to submit tamely to his usurpation; but he addressed each of the belligerent powers *separately*, with the obvious view of dissolving the coalition; and he repealed not the decrees of the Convention, which declared war against all the governments of Europe. Deviating from the forms long established for transacting business between independent states, he addressed the British government, not, as usual, through the medium of the minister for foreign affairs, but in a letter directed immediately to the King; to that letter he prefixed a motto, which proved his own adherence to the revolutionary decrees that were the chief cause of the rupture with England; and it is difficult to believe that he did not actually *mean* to insult the monarch whom he so addressed.

He certainly did not expect a proposal made in such a manner to be listened to, or that the King would deign to answer a letter which began with proclaiming *liberty*, *equality*, and the *sovereignty of the people*. Besides this revolutionary jargon, the letter contained nothing more than the two simple questions—"Whether the war, which had, for eight years, ravaged the four quarters of the globe, was to be eternal?" and "whether there were no means for Britain and France of coming to a good understanding?" His Majesty's ministers would have been perfectly justified had they returned, to the former of these questions, the laconic answer, *No;* and to the letter, *Yes:* but they condescended to assign the reasons which prevented the King from listening to overtures coming, in so questionable a shape, from so novel an authority.

397 Rejected by Britain

Those reasons were unanswerable; for they rested on past experience of the bad faith of the revolutionary rulers of France; on the instability of the consular government; and on the obligation of treaties, by which his Majesty was bound not to abandon his allies by concluding a separate peace.

That the revolutionary rulers of France had been remarkable for bad faith, was completely proved in both houses of parliament, by an enumeration of the treaties which Bonaparte himself, when commanding the armies of the republic, had first entered into with foreign states, and then violated. That the consular government was then unstable, will be questioned by no man, who, reflecting on the means by which it was formed, adverts to the circumstance of the letter to the King being written on the very day on which the Consuls were installed in their office, and long before it could be known that the primary assemblies would accept the constitution which had been dictated to them. That constitution had, indeed, deviated so far from all republican forms, as to excite discontent even among its own creatures; and, in the first meeting of the tribunate, one of the members, obviously comparing the new with the old government, talked of the idol of fourteen days, which, he observed, might as readily be overthrown as the idol of fourteen ages. That the First Consul was sincere in wishing to restore peace to *Europe*, will hardly be supposed by him who calls to mind, that the French minister, in his reply to Lord Grenville, took not the smallest notice of the *allies*, although he had been assured by his Lordship, that his Majesty could not treat without them. It is likewise worthy of remark, that in the last official paper on the subject, the same minister proposed, not any specific terms of peace, but merely an *immediate suspension* of hostilities between the two nations, and the naming of plenipotentiaries, who should repair to some convenient place, and apply themselves, with all possible dispatch, to the effecting of a good understanding between the French republic and England! Had that proposal been agreed to, the ports of France, which were then blocked up by the British fleet, would have been opened for the importation of naval stores; the negociation might have been 1800.
protracted from day to day; and when the Consul had conquered the Austrians in Italy and on the Rhine, he might have suddenly broken it off, and directed the whole force of the republic against the British empire.

All this was foreseen by those who at that period so ably guided the helm of state, and the insidious overture was with dignity rejected.

398 And the court of Vienna.

A similar overture had been made to the court of Vienna, and treated in the same manner; but early in this year, the Emperor of Russia withdrew from the coalition. He had been highly and justly offended by the conduct of Austria during the last campaign: he is said to have demanded Malta of the British court as soon as it should surrender to the combined forces of Russia and England, and to have received, with the utmost indignation, the refusal which was given to so unreasonable

French Revolution, 1800. reasonable a demand; but such was his caprice, that the motives which induced him to abandon his allies may have been much more trifling than either of these. Whatever they were, he issued the most peremptory orders to Suwarrow to retire with the army under his command into Poland; and with these orders the old man reluctantly complied about the middle of January. The Emperor continued, indeed, to express the utmost abhorrence of the French revolution, and of the principles whence it had sprung; but his warlike operations were now at an end; and the Consuls heard, with indifference, of his prohibiting the importation of French books into the Russian empire.

399 Defection of the Emperor of Russia.

In the mean time, Bonaparte succeeded in suppressing an insurrection, more formidable, if credit be due to the papers which were said to be found in the possession of the chief insurgents, than any that had yet been raised in behalf of the house of Bourbon; and being thus relieved from the anxiety inseparable from a civil war, he found leisure to turn his attention to his foreign enemies.

On the 7th of March he sent a message to the legislative body, in which, after misrepresenting, in the grossest manner, the conduct and views of the court of London, he assured them, that in the midst of battles and triumphs, he would invoke peace, and swear to fight only for the happiness of France, and the repose of the world! This message was followed immediately by two decrees: the one calling, in the name of honour, upon every soldier who was absent on leave from the armies in Italy and on the Rhine, or who, on account of his age, had retired from the service, to join his regiment before the 5th of April, if able to serve another campaign; and the other, appointing a fresh army of reserve, consisting of 60,000 men, to be assembled at Dijon, and to be placed under the command of the First Consul in person.

400 Preparations of France for opening the campaign.

Amid these warlike preparations, which were carried on with vigour, the government did not neglect the administration of justice, or the internal economy of the state. Hitherto the several departments, into which the constituent assembly had divided the kingdom of France, were under the controul of what were called *central administrations*; but they were now subjected to the government of magistrates styled *præfects*, who were nominated to their office by the Chief Consul. In every department there was appointed one præfect, with three or four sub-prefects, according to the population; and one of the offices of the council of præfecture was to decide on the remonstrances of the citizens against their quota of taxation. A reformation was likewise introduced into the civil and criminal courts of justice, of much greater importance to the inhabitants of France than the institution of præfects. The judges were to be no longer chosen by the people for a limited time, but to be appointed, with decent salaries, by the Chief Consul; nor were they to be liable to such interruptions as formerly in the discharge of their duty. The good effects of this reformation were quickly seen in the more prompt and equal administration of justice, and in the less frequent employment of the guillotine.

401 Internal regulations.

The campaign was now ready to be opened both in Italy and on the Rhine. The only territory of any importance which, in Italy, remained in the possession of France, was that of the Genoese republic; and the army which they had to defend it was greatly reduced in numbers since the preceding year, and, for want of clothes, provisions, and pay, was in a state little short of mutiny. It was the great object of the Austrians to get possession of Genoa, with all its dependencies; while the Genoese, who beheld in the French only the destroyers of their commerce and their consequence, were disposed to lend every aid to measures calculated to drive them effectually from their country. French Revolution, 1800.

The command of the French army in Genoa was given to Messena; who, having received from the Consuls extraordinary powers, displayed, in that command, all the abilities of a consummate general. Carrying with him from Lyons and Marseilles a supply of troops, and, by a proper distribution of rewards and punishments, reducing to order and obedience those whom he found ready to desert their standards, he was soon at the head of a force able, not only to overawe the inhabitants, but to stop the progress of the Austrians. After many battles and skirmishes, however, he was at last obliged to retire into the city, where famine would have compelled him to surrender immediately, had he been immediately blockaded by the army under the command of the Imperial General Melas. 402 Messena

The appearance of the British fleet, on the 5th of April, was the signal for that general to attack the place. The communication between Genoa and France by sea was now cut off; but a few days preceding the arrival of Lord Keith, a quantity of wheat, and other provisions, had entered the port, and rescued the inhabitants and the army from the last pressure of famine. The Austrians soon made themselves masters of the surrounding country; but Messena, in hopes of receiving succour from France, obstinately refused to give up the city. Although reduced to act on the defensive, he neglected no opportunity of making sallies on the enemy, sometimes with considerable slaughter on both sides: but he is said to have tarnished the laurels which his bravery would have gained, by exhibiting his prisoners to the contempt of the citizens. An engagement of this kind, in which he lost three of his best commanders, terminated all further operations on his part; and General Melas, having nothing more to apprehend from the army cooped up in Genoa, left General D'Ott to continue the blockade, and turned his own forces against *Sauchet*, who commanded a separate division of the French army. 403 Blocked up in Genoa.

On the 7th of May was fought, between Ceva and St Lorenzo, a decisive battle, in which the French were totally defeated, with the loss of 19 pieces of cannon, and 1200 prisoners, among whom were 357 officers, one of whom was a general of division. Soon after this action, Sauchet was compelled to abandon the strong position of Col di Tenda, leaving behind him four pieces of cannon and 200 prisoners; and advancing towards Niece, he was driven from post to post, till at last he was obliged to take shelter behind the Var, leaving Melas in possession of the whole department of the Maritime Alps. 404 Sauchet defeated.

The opening of the campaign on the Rhine was not so favourable to the Austrians. For reasons, which we pretend not to know, the Archduke Charles had been directed by the court of Vienna to resign the command of the army to General Kray, who had so much distinguished himself in Italy during the campaign 1799. 405 The campaign opened on the Rhine.

French Revolution, 1800.

The military talents of Kray were unqueſtionable; and he had gained ſufficient evidence of his integrity and zeal for the cauſe, both when ſerving under Suwarrow, and when acting independent of him; but, unfortunately, he was a ſtanger to the army which he now commanded, and he was not ſo *noble* as ſome of the other generals! Our attachment to democracy will not be ſuſpected; but the principles of no democrate have been more abſurd than the prejudices of part of the Germans in behalf of *nobility*. Becauſe one of the generals ſerving under Kray was more noble than his commander, he had the folly and inſolence to declare, that he would obey no order of which he was not himſelf convinced of the propriety (A); whilſt many of the inferior officers, who had riſen from the ranks, and were deeply tinctured with the principles of Jacobiniſm, refuſed to fight againſt thoſe whoſe object it was to level nobility with the duſt.

That an army, thus commanded, would make effectual head againſt the French veterans, led on by the gallant Moreau, could not reaſonably be expected; and the reader will not be ſurpriſed, that the Hungarian ſoldiers, though they had given repeated proofs of their bravery, made no reſiſtance to the enemy, when they ſaw themſelves ready to be ſacrificed to the diſſentions of their own officers.

406 The Auſtrian General Kray

Kray had received, at the opening of the campaign, orders from the Aulic council how to diſpoſe of the forces under his command; and being unſupported by the generals under him, he had no other alternative than to obey theſe orders, whether he approved of them or not. Similar inſtructions had been ſent by the Conſul to Moreau, containing a detailed plan of operations which he was commanded to execute; but he ſpiritedly refuſed to fight in ſuch fetters.

Conſcious, it may be preſumed, that his own knowledge of the art of war was at leaſt equal to that of Bonaparte, while his experience of the country was infinitely greater, he diſpatched a courier to Paris to inform the Conſuls, that if the orders which he had received were to be rigidly followed, he muſt beg leave to reſign his command, and take a ſecondary rank. His reſignation was accompanied with the plan of operations which he had formed for himſelf; and the Firſt Conſul, inſtantly perceiving its propriety, continued him in the command, with inſtructions to carry on the war according to his own judgment.

407 Driven from poſt to poſt by Moreau.

Moreau, thus left to act according to circumſtances, eaſily croſſed the Rhine, and drove the Auſtrians from poſt to poſt, till Kray, finding it impoſſible to act offenſively with a mutinous army, commanded by diſaffected officers, determined to maintain his poſition at Ulm, and wait for ſuccours from Vienna. He had been defeated at Stokach, at Engen, and at Moſkirch; but, though he had on theſe occaſions diſplayed all the talents of an able general, we enter not into a minute detail of battles, in which no talents could counteract the effects of treachery. On one occaſion, 7000 men, who were ordered to advance, immediately threw down their arms; and on the night previous to one of theſe actions, ſeveral officers were heard to ſay, that the ſoldiers whom they commanded *would not fight!* With ſuch a ſpirit in the army, offenſive operations were no longer practicable; but Ulm, as it commanded both ſides of the Danube, was of ſo much importance, that the gallant veteran, having ſtrongly entrenched himſelf, reſolved, if poſſible, to maintain his poſition.

408 Makes a ſtand at Ulm;

Moreau, who penetrated into his deſigns, determined to attempt the paſſage of the Danube, and by cutting him off from his magazines at Donavert, to force him to a general action. Accordingly he ordered Lecourbe, who commanded one of the wings of his army, to advance, and take poſſeſſion of a bridge between Donavert and Dillingen. This was accompliſhed with difficulty; for the Auſtrians, perceiving, when too late, that all was at ſtake, diſputed every inch of ground with the French general. During the interval of marching to the Danube and croſſing it, Kray, who perceived the intentions of his enemy, had ſent conſiderable reinforcements to the left bank to oppoſe the paſſage. In conſequence of this, a battle took place at the celebrated poſition of Hochſtet, near Blenheim, which ended in favour of the French, who took 4000 priſoners, without counting the killed and wounded.

Kray, who ſaw the danger of his poſition, aſſembled his forces, and leaving a ſtrong garriſon in Ulm, marched againſt the French; and paſſing by Hochſtet, croſſed the Danube at Newburg, with the ſeeming intention of forcing his enemy to abandon the ground which he occupied on the left bank of the river near Ulm.

409 But, defeated at Newburg, falls back to Ingolſtadt.

The French army received his attack at Newburg; and the engagement, which commenced early in the day, was continued, with the moſt determined bravery on both ſides, till night; when the Auſtrians, obliged to retreat, fell back on Ingolſtadt.

This battle decided the fate of Germany. The French became maſters of the electorate Bavaria, and of various territories of leſs extent; and as they approached the hereditary dominions of the Emperor, the Jacobins, not only of the capital, but of the whole of Upper Auſtria, behaved with ſuch audacity, that the court could not but perceive that no dependence was to be placed on armies compoſed of ſuch men. The Imperial family, and the Britiſh ambaſſador, were publicly inſulted in the theatre; whilſt a hired rabble vociferated "Peace! Peace!"

410 The army of reſerve,

This ſpirit was not rouſed by the ill ſucceſs of Kray alone; for the affairs of Auſtria were now more deſperate in Italy than even on the Danube. About the ſame period that the campaign opened on the Rhine, the army of reſerve, which had been for ſome time forming at Dijon, began its march. The French government had given official notice, that this army was already compoſed of more than 50,000 men; that it was receiving reinforcements every day; and that it was prepared to march either to the right or left, as the chance of war, or the plans of government, ſhould render the one route or the other neceſſary. This account was not generally credited. Thoſe who wiſhed well to the cauſe of the allies, were unwilling to allow ſuch vigour

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(A) This man afterwards boaſted of his diſobedience at Vienna: "Je ne voulois pas etre commandé par un roturier," ſaid he. "Non! (replied the gentleman to whom he ſpake) vous aimiez mieux etre battu par un roturier."

gour to the French government ; while the Jacobins of Germany induſtriouſly circulated a report, both through Italy and the empire, that the army of reſerve amounted to little more than 6000 men.

On the 5th of May, the Firſt Conful left Paris to take upon himſelf the command of this army ; and after receiving the troops cantoned at Dijon, he paſſed on towards Genoa. Remaining a ſhort time in the
411 Pays de Vaud, he joined the army of reſerve at the foot of Mount St Bernard, and inſtantly aſſumed the command. A very ſmall force would have been ſufficient to ſtop that army in its aſcent ; but General Melas either heard not of its being in motion, or believed implicitly the inſidious report circulated by the Jacobins of Italy and the empire. The French, therefore, met with no reſiſtance till they reached the town of Aoſt, of which, after a very ſlight ſkirmiſh, they took quiet poſſeſſion. Having, with incredible perſeverance and addreſs, paſſed by the fortreſs of Bard, they purſued their route down the valley of Aoſt, with little oppoſition till they reached the town of Yorea. There, indeed, the Auſtrians had aſſembled a force, but a force which, as it was inadequate to the defence of the place, the impetuoſity of the French ſoon compelled to give way, and take poſt on the heights of Romano behind the Chinſella. That poſt was of great importance, as it commanded the paſſage of the river ; but it was occupied by no more than 5000 infantry, 4000 cavalry—of little uſe in ſuch a ſituation, and a few pieces of artillery. The conſequence was, that on the 26th of May it was forced, with conſiderable ſlaughter, indeed, on both ſides ; and ſoon afterwards the fort Brunette, which commanded the entrance to Piedmont on the ſide of Suſa, capitulated to another diviſion of the army under the command of General Turreau ; ſo that the road to Turin was now open.

Under the command of the Firſt Conſul, croſſes the Alps.

412 While the French were paſſing the St Gothard, the main body of the Auſtrian army was occupied in the remoteſt parts of Piedmont, celebrating their victories over the French at Nice. It is difficult to decide whether the raſh confidence of Bonaparte, or the thoughtleſs ſecurity of General Melas, ought, on this occaſion, to excite the greateſt aſtoniſhment ; for it is certain, that a proper diſpoſition of a very ſmall portion of the Auſtrian forces among the paſſes of the Alps, would have cruſhed at once the army, and all the proud proſpects, of the Conſul.

Thoughtleſs ſecurity of the Auſtrian commander.

Rouſed at length from his dreams of ſafety, by the news of an invaſion, of which he had been often warned, and which he would even yet ſcarcely believe, Melas flew to Turin, recalling, by haſty marches, the main body of his army, to defend the Po, and prevent the enemy from getting poſſeſſion of the capital. It was natural for him to ſuppoſe that Turin would be the firſt place of importance attacked by the French ; and the Conſul gave countenance to that ſuppoſition, by ſeeming to menace the paſſage of the Po. He had formed, however, a different plan of operations ; and while the Auſtrian commander was preparing to diſpute with him the paſſage of the river, he ſuddenly turned to the left, and, croſſing the Seſia and the Teſſino, entered Milan on the 2d of June.

413 Whilſt Bonaparte marched to Milan, General Lannes, with the advanced guard, filed off towards Pavia. The French army, though ſtrong in numbers, had neither magazines, artillery, nor ſtores of any kind ; and learning that Pavia was the great depot of the Auſtrian army, the Conſul was determined to make himſelf maſter of it. This was eaſily accompliſhed ; and Lannes 414
found in the place upwards of 200 pieces of artillery, 8000 muſkets, 2000 barrels of gunpowder, and an immenſe quantity of all kinds of proviſions.

Bonaparte enters Milan; Takes Pavia;

The religious profeſſions of Bonaparte had, at all times, been accommodated to the principles or prejudices of thoſe whom he wiſhed to attach to his cauſe. In Egypt he had kept the feſtival of Mohammed, and declared himſelf ſent by the Moſt High to enforce obedience to the laws of the prophet ; and, with equal ſincerity, he now ſung *Te Deum* in the cathedral church of Milan, for the happy deliverance of Italy from *heretics* and *infidels !* He then proceeded to the formation 415
of a proviſionary conſtitution for the Ciſalpine republic ; which, in a few days, was re-organized as a free and independent ſtate.

And reſtores the Ciſalpine republic.

Whilſt the Conſul was diſplaying his talents as a conſtitution-monger, one of his generals, with a detachment of the army, croſſed the Po at Stradella, and, cutting off the communication between General Melas and the country of Piedmont, made himſelf maſter of the Auſtrian magazines at Piacenza, Cremona, and various other depots on the banks of the river. 416

It was at this time that Bonaparte, by means of intercepted letters, was firſt informed of the capitulation of Genoa. Maſſena had done every thing in the power of valour and perſeverance to defend the place ; but after he had ſeen 15,000 of the inhabitants periſh by hunger, he was obliged, on the 5th of June, to ſurrender to the Britiſh and Auſtrian commanders. Conſidering his utter inability to hold out longer, the terms which he obtained were favourable. The right wing of his army, to the number of 8110 men, were to march into France by the road of Nice, and the remainder was to be tranſported by ſea, at the expence of Britain, to Antibes ; no man was to be held reſponſible for having exerciſed any public function under the government of the Ligurian republic ; and all officers made priſoners from the beginning of the campaign, were to return to France on their parole, and not to ſerve till regularly exchanged.

Genoa ſurrendered to the allies.

The ſurrender of Genoa left the Auſtrian army, by which it had been inveſted, at liberty to co-operate with the commander in chief ; and General D'Ott marched, with thirty battalions, to oppoſe the progreſs of the 417
French in Piedmont. He was met, on the 9th of June, at a place called Montebello, by a large detachment of the French army under the command of the Generals Lannes and Victor. The battle raged long with great fury, and the village of Caſteggio, which at its commencement was in the poſſeſſion of the Auſtrians, was taken and retaken ſeveral times ; but at laſt victory declared for the French, and General D'Ott retired with great loſs.

The Auſtrian General D'Ott defeated at Montebello.

Unable to ſtop the progreſs of the French by partial detachments, Melas, who was now blockaded in Piedmont, aſſembled the whole of his forces between Aleſſandria and Tortona, in order, by one ſtroke, either to cruſh the enemy, or at leaſt open to himſelf a way to the Auſtrian diviſions on the Mincio. This produced, on the 14th of June, the memorable battle of Marengo ; of which we ſhall attempt no detail, becauſe we could

could give none for the truth of which we would chooſe to be anſwerable. The French accounts, which are faithfully copied by our own Jacobinical writers of
418 The battle of Marengo. periodical hiſtory, repreſent the army under the command of Melas as more numerous than that of the Conſul; while they attribute the ſucceſs of the latter wholly to the conduct and intrepidity of its leader. The fact, however, we believe to be far otherwiſe; for we think it might be proved, by comparing together the different bulleteins of the army of reſerve, that from the beginning the French had a decided ſuperiority. Be this as it may, the Auſtrians were, for nine hours, victorious; and the fate of the battle was at laſt turned, not by any uncommon exertions of the Conſul, but partly by the provident conduct of Deſſaix, and ſtill more by the ſituation of the Auſtrian commander, whoſe faculties ſeem wholly to have forſaken him in the latter part of the day. When he was in this ſtate, one falſe movement, which weakened his centre, afforded an opportunity to Deſſaix to make a vigorous and ſucceſsful charge with a body of cavalry that had not yet been engaged; and General Zach, who was about to take the command of the army from Melas, worn out with age and fatigue, unfortunately falling, at that critical moment, into the hands of the enemy, the French remained maſters of the field of battle.

The ſpirit of the Auſtrians, however, was not broken. They had loſt indeed 9000 men, with ſome of their beſt generals; but the loſs of the French was confeſſedly greater, amounting by their own account to at leaſt 12,000 men. The Auſtrians, enraged at having had the victory ſo wreſted out of their hands, were eager to renew the conteſt on the following day; but, inſtead of ſeconding the ardour of his troops, General Melas concluded a capitulation, unparalleled, we will venture to affirm, in the annals of war; a capitulation by which he voluntarily ſurrendered into the hands of
419 Its conſequences. the enemy nearly all the fruits of one of the moſt glorious and ſucceſsful campaigns recorded in hiſtory. We wiſh not to throw any undue aſperſion on the character of the Auſtrian commander. His behaviour at the battle of Novi renders his bravery unqueſtionable; and we are aſſured, by letters from Germany, that his integrity has never been ſuſpected; but thoſe letters repreſent him as qualified, not to command a great army, but only to execute the orders of a ſuperior mind. It may have been in conſequence of ſome previous general inſtructions from the Aulic Council that he ſigned ſuch a capitulation; or the fortreſſes which he ſurrendered may have been deſtitute of proviſions, and of courſe incapable of ſuſtaining a ſiege. On the former ſuppoſition, the Aulic Council muſt be conſidered as decided enemies to the cauſe in which the allies were embarked; on the latter, General Melas was the leaſt provident commander that was ever perhaps entruſted with the defence of a country.

420 An armiſtice in Italy. Be this as it may, he gave up to the French the whole of Piedmont and Genoa; and, concluding an armiſtice which was to laſt till an anſwer agreeing to the conditions could return from the court of Vienna, he retired with his army into the territory of Mantua, Tuſcany, and Ancona.

The gallant Kray wiſhed to take advantage of this armiſtice in Italy to ſtop the progreſs of the troops under Moreau; but the French general would not liſten to his overture, till he received inſtructions from Paris, in conſequence, as was ſuppoſed, of the arrival of Count St Julien with propoſals of peace from the Imperial Cabinet. The armiſtice was then concluded in Germany as well as in Italy, leaving for the line of demarcation the poſts occupied at the time by the reſpective armies; but if the French adhered to the letter of theſe treaties, they almoſt inſtantly violated the ſpirit of both. They reinforced their army in Italy in direct contradiction to what was obviouſly the meaning of their ſtipulations with Melas; they filled the conquered countries with their licentious hordes; they levied enormous contributions, and even raiſed troops in ſtates of which they had formally proclaimed the *independence*; and their armies in Germany ſubſiſted on the plunder of the neighbouring countries. 421 And Germany.

Whilſt France was thus everywhere victorious in Europe, her troops were ſuffering hardſhips and diſgrace in Africa. They complained loudly of being deſerted by their chief; and Kleber, on whom the command devolved, declared, in the impious jargon of the Jacobins, that the ſame *univerſe* ſhould not contain him and Bonaparte. He felt it expedient, however, to continue the negociations into which that general had entered with the Grand Viſier for the evacuation of Egypt; and after many letters had paſſed between them, a convention was concluded on the 24th of January 1800, to which Sir Sydney Smith acceded on the part of Great Britain. By that convention the French army was to be collected with its arms, baggage, and effects, at Alexandria, Roſetta, and Aboukir, and thence be tranſported into France, as well in its own veſſels as in ſuch as ſhould be furniſhed to it by the Sublime Porte. 422 State of the war in Egypt.

To the cauſe of the allies it is obvious that nothing could have happened apparently more injurious than the evacuation of Egypt on ſuch conditions as this, which would have furniſhed the Conſul with ſixteen or eighteen thouſand veteran troops to be employed by him either in Italy or on the Rhine. How the gallant Commodore came to overlook this circumſtance, or indeed how he came to act as a Britiſh Plenipotentiary, we pretend not to know. That he exceeded any powers with which he could reaſonably conceive himſelf veſted, was completely proved in the Houſe of Commons by the war-miniſter Mr Dundas; who juſtly obſerved, that the powers of Sir Sidney and his brother as plenipotentiaries, had ceaſed upon the arrival of Lord Elgin in that capacity at Conſtantinople; and that, as a Britiſh officer, he had no right to accede to ſuch a convention while he held only a ſubordinate command under Vice-admiral Lord Keith.

In December 1799, miniſters had reaſon to believe that a negociation would be entered into by General Kleber and the Grand Viſier for the evacuation of Egypt by the French troops. As ſuch a negociation was deſirable, they ſent inſtructions, not to Sir Sidney Smith, but to Lord Keith, to accede to it; on the expreſs condition, however, that Kleber and his forces ſhould not be ſent back to France to fight againſt the Auſtrians, but ſhould be detained as priſoners of war till regularly exchanged. Theſe inſtructions reached the noble admiral in February 1800, when he immediately appriſed General Kleber of them; aſſuring him, at the ſame time, that he would permit no ſhips to ſail with French troops, in conſequence of any partial capitulation,

French Revolution, 1800.

pitulation, or of paſſports from ſuch as had no right to grant them.

This conduct, which was perfectly fair on the part of Britain, and of which the contrary might have been juſtly complained of by the court of Vienna, produced a violent outcry, not only in France but even in England, among thoſe who, from the commencement of the war, had uniformly pleaded the cauſe of the enemies of their country. Government, it was ſaid, had broken faith both with its allies and with its enemies; yet Kleber himſelf accuſed the cabinet of St James's of no ſuch crime. He talked, indeed, of Lord Keith's *inſolence*, and called upon his ſoldiers to anſwer it by their victories; but ſo little did he dream of treachery on the part of Britain, that in his letter to the directory, he ſpoke of his convention as made with the Grand Viſier alone. Accordingly, on the 20th of March, he attacked the Turks in the neighbourhood of Cairo; and though the Janizaries diſplayed ſomething of their wonted bravery, they were forced to yield to the ſuperiority of European tactics, when the Turks fled in all directions, leaving upwards of 8000 dead and wounded on the field of battle.

This victory reſtored to the French the poſſeſſion of Cairo, which they had abandoned in conſequence of the convention; but they were ſtill much haraſſed by ſome of the Beys, who during the battle had paſſed the rear of the army, and maſſacred ſuch of the Copts as favoured their cauſe. Kleber, therefore, again propoſed to evacuate Egypt on the terms agreed to by the Grand Viſier and Sir Sidney Smith; and the court of London having authoriſed Lord Keith to accede to thoſe terms, a ſuſpenſion of hoſtilities took place, and
423 the Turks were about to be freed from enemies whom they were unable to expel, when the French commander was ſuddenly aſſaſſinated.

Aſſaſſination of General Kleber.

This was a ſerious misfortune, as well to the allies as to the French in Egypt; for Kleber appears to have been the moſt honourable, as well as the ableſt, commander of the republicans in that part of the world. By whom, or at whoſe inſtance, he was murdered, is not certainly known; but, at Conſtantinople, ſuſpicion attached ſtrongly to his ſucceſſor Menou, who had thwarted all his meaſures; who reſolutely oppoſed the evacuation of Egypt on any terms; and who, having embraced the Mahommedan faith, prefixed *Abdullah Bey* to his name. He no ſooner ſucceeded to the command of the army, than he broke off the negociation which was almoſt concluded by his predeceſſor; and informed the Engliſh Commodore, on the 19th of June, that he could enter into no treaty without inſtructions from the Conſuls, who, as he truly obſerved, then *governed* the French nation.

In the mean time, meaſures were taken by the Britiſh government to drive him from that country, which he would not leave by capitulation. Early in the campaign, a body of 12,000 men had been put under the command of Lieutenant-general Sir James Pulteney, to act in the Mediterranean in ſuch a manner as might moſt annoy the enemy, and divide their force. The deſign was ſplendid; but it was completely diſconcerted by the fatal iſſue of the battle of Marengo. The force under Sir James, however, might ſtill be employed with advantage to the common cauſe; and as there was reaſon to believe that France and Spain had formed the plan of marching an army into Portugal, the lieutenant-general was directed to reconnoitre Ferrol, and make an attempt upon the place, ſhould he deem ſucceſs probable, with little loſs of men and of time. He landed 424
his troops on the 25th of Auguſt, and got poſſeſſion of the heights which overlooked the town; but finding it better fortified, and occupied by a ſtronger garriſon, than he had expected, he judged ſucceſs unattainable, without ſuch a loſs of men as would render the army incapable of carrying into effect the objects of its future deſtination. He therefore reimbarked, on the morning of the 27th, without having ſummoned the garriſon, thrown a ſhell into the town, or fired a ſhot againſt the ramparts.

Sir James Pulteney at Ferrol.

425
Sir Ralph Abercromby had been ſent to ſuperſede Sir James Pulteney, and take upon himſelf the command of the army acting in the Mediterranean. Having carried reinforcements with him, beſides a train of artillery from Gibraltar, he touched at Minorca and Malta, whence he proceeded towards the coaſt of Egypt. Meeting, however, with unexpected delays on the coaſt of Aſia Minor, the forces, under the joint command of Lord Keith and him, did not arrive at Alexandria till the 1ſt of March 1801. On the following day the fleet made ſail for the Bay of Aboukir, where it anchored. The ſea running high, no diſembarkation could be attempted till the 7th, when, at 10 426
o'clock A. M. the firſt diviſion made good its landing in the face of the French, who, to the number of 4000 men, were poſted ſo advantageouſly, that, in the opinion of an eye-witneſs *, they might have reſiſted the world. Our limits permit us not to dwell on the maſterly plan of the commander in chief, or on the cool intrepidity of General Moore in carrying it into execution. Suffice it to ſay, that by 2000 Britiſh troops the enemy were driven from their poſition with the loſs of ſome field pieces, which were immediately turned againſt them; and that the diſembarkation was continued during that and the following day.

Sir Ralph Abercromby

Lands in Egypt:

* Mr Baldwin. See his *Political Reflections relative to Egypt.*

On the 12th the whole army moved forwards, and coming in ſight of the main body of the French, attacked them on the 13th, when, after an obſtinate conteſt, and conſiderable loſs on both ſides, victory declared 427
for the gallant Abercromby. The blow was followed up with vigour; and on the 21ſt a ſtill more deciſive battle was fought, with a ſimilar event, at the diſtance of about four miles from Alexandria. It commenced early in the morning, and was continued long; victory leaning ſometimes to one ſide and ſometimes to the other; but at laſt the French gave way in all directions. The heroiſm diſplayed in this brilliant action raiſed the military character of the Britiſh nation as high as its naval character; and the magnanimous conduct of the commander in chief, who, that the ardour of his troops might not be damped, concealed, for two hours, the 428
bitter anguiſh of a mortal wound, has ſeldom been equalled, and can hardly be ſurpaſſed. The loſs on our ſide, in killed, wounded, and miſſing, was upwards of 1500, among whom were ſeveral gallant officers beſides the general. The loſs of the French was computed at 4000.

Fights the battle of Alexandria.

In which he is mortally wounded.

As theſe two battles may be ſaid to have decided the fate of Egypt, we ſhall return to Europe, where events had taken place of as great importance as any which had occurred during the war. The northern powers,

powers, long envious of the naval superiority of Britain, and influenced by the Emperor Paul, who seemed now to be leagued with the Conful of France, had re-
429 The northern confederacy. vived the armed neutrality firft formed by Catharine II. during the American war; and claimed the right of treading to the ports of France, without having their veffels fearched by the Englifh cruifers. That confederacy the Britifh minifters had determined to break, when, to the furprife of the whole nation, and the deep regret of the better part of it, they fuddenly retired from office.

Of a meafure fo little expected, various caufes have been affigned; but that which was in a manner avowed
430 The refignation of the miniftry. in parliament, was a difference in the cabinet refpecting Catholic emancipation. With much addrefs the miniftry had accomplifhed a legiflative union between Great Britain and Ireland (See IRELAND, in this *Suppl.*); and it has been faid, but certainly not proved, that the Lord Lieutenant had been authorifed, to hold out to the Irifh Catholics a repeal of the *teft act*, as an inducement to them to comply with the meafure. Such a bribe as this, clandeftinely offered, is very unlike the fpirit as well of Mr Pitt as of the Marquis Cornwallis; and we do not believe that the offer was ever made. There feems, however, to be no doubt but that the minifter propofed the meafure in the cabinet after the union; that the king, with that confcientious regard which he has uniformly difplayed to the conftitution, put his negative upon it; and that in confequence Mr Pitt and his friends immediately gave in their refignation.

Their places were fupplied by men who had generally fupported their meafures during the war; and it
431 The new miniftry has even been fuppofed that thofe who retired from office recommended their fucceffors. Mr. Addington, then fpeaker of the Houfe of Commons, was appointed firft lord commiffioner of the treafury and chancellor of the exchequer; Lord Eldon, lord high chancellor; the Earl of St Vincent, firft lord commiffioner of the admiralty; Lord Hawkefbury and Lord Pelham, fecretaries of ftate for the foreign and home departments; and the Hon. Colonel Yorke, fecretary at war. The old miniftry was diffolved on the 11th of February; but, owing to a fevere illnefs of his Majefty, it was the middle of March before any of the new minifters, except Lord St Vincent and Lord Hawkefbury, entered upon their offices; and during that period of difmay, Mr Pitt and his friends guided the helm of ftate.

The new minifters began their career with pledging themfelves to leave nothing unattempted to bring about a fafe and honourable peace with the French republic; but in the mean time they proceeded with vigour to carry into effect the warlike plans of their predeceffors.

432 Fit out an armament againft the powers of the North, The northern confederacy had by this time adopted meafures the moft hoftile. A Danifh army under the command of Charles Prince of Heffe took poffeffion of the free and imperial city of Hamburgh, for the exprefs purpofe of hurting the Britifh commerce; and the King of Pruffia, with that unaccountable policy which has marked the whole of his conduct, ordered a large army into the electorate of Hanover. To chaftife this infolence and diffolve the confederacy, an armament was fitted out in the Britifh ports, confifting of feventeen fail of the line, four frigates, four floops, and fome bomb veffels. This fleet, under the command of Admiral Sir Hyde Parker, Vice-Admiral Lord Nelfon, and Rear-Admiral (now Sir Thomas) Graves, failed from Yarmouth on the 12th of March; and paffing the Sound, appeared on the 30th before Copenhagen. The Danes feemed undifmayed; for neither the town nor their fleet could be annoyed, but by the Britifh admiral's conducting their force through a channel of fuch intricate navigation, that, thirty years before, it was thought hardly fafe to attempt it with a fingle fhip oppofed to no enemy. Lord Nelfon, however, having founded the channel, undertook to pilot through it a large divifion of the fleet, of which he requefted and obtained the command from Sir Hyde Parker, with Rear-Admiral Graves commanding immediately under him.

433 Which deftroys the Danifh fleet, &c. at Copenhagen. As the fecond rates were thought to draw too much water for fuch a navigation, the twelve fhips felected for the attack carried each from 74 to 50 guns, to which were added four frigates, four floops, two fire-fhips, and feven bombs. The force oppofed to this armament was tremendous, confifting of fix fail of the line; eleven floating batteries, mounting each from 26 twenty-four pounders to 18 eighteen pounders; one bomb-fhip, and feveral fchooner veffels in the line. Thefe were fupported by the Crown Iflands, mounting eighty-eight cannon; by four fail of the line, moored in the harbour's mouth; and by fome batteries on the Ifland of Amak. This force Lord Nelfon attacked on the 2d of April; and after an obftinate action for four hours, filenced the batteries, and took, burnt, or funk feventeen fail, among which were feven fail of the line. On both fides the carnage was great, the Britifh having 943 men, including officers, killed and wounded; whilft the lofs of the Danes was at leaft double that number.

434 The refult of this action. The refult of this brilliant action, to which nothing will be found fuperior in the annals of naval war, was a fufpenfion of hoftilities, and, on the part of Denmark, of the treaty of armed neutrality, for fourteen weeks.

As foon as the difabled fhips were repaired, the Britifh fleet failed for Carlfcrona, off which it appeared on the 19th of April. The admiral immediately acquainted the governor with what had been tranfacted at Copenhagen, requefting from his Swedifh majefty an explicit anfwer whether he meant to adhere to or abandon the hoftile meafures which he had taken in conjunction with the court of Peterfburgh. The anfwer returned was extremely equivocal; but intelligence be- 435
And of the death of the Emperor Paul. ing received of the fudden death of the Emperor Paul on the 23d of March; and Lord Nelfon, who had fucceeded Sir Hyde Parker in the command of the Britifh fleet, writing in more decided terms than his predeceffor, the court of Stockholm followed the example of that of Copenhagen. The young Emperor Alexander foon afterwards, actuated by a fenfe of juftice, reftored the Britifh property which his father had confifcated; relinquifhed his ill founded claims to the ifland of Malta, 436
Surrender of Malta. which by this time had furrendered to the Britifh forces; and agreed to a fearch of neutral fhips bound to the ports of a nation at war with another. It was indeed to fuch a fearch only by fhips employed entirely in the fervice of government that his Imperial Majefty thus agreed; but this is perhaps all that the Britifh government could reafonably afk; and the granting of it put an end to the northern confederacy.

At the figning of the armiftice between the Auftrian and French generals in 1800, the Republican troops were

French Revolution, 1800.

were maſters of Germany almoſt to the banks of the Inn, and of Italy almoſt to the confines of Venice. The ſpirit of the Emperor, however, was not yet broken, and he refuſed to abandon his allies by confirming the preliminaries of peace to which Count St Julian, exceeding his powers, had agreed at Paris. General Kray having retired from the ſervice, the command of his army was given to the Archduke John, and the Emperor in perſon repaired to it with him; but they ſoon found it incapable of acting offenſively againſt Moreau, and another armiſtice was agreed to, including Italy as well as the empire. The conduct of the Emperor was, on this occaſion moſt honourable. He wiſhed to comprehend Great Britain in any treaty of peace to be negotiated between himſelf and the Conſul; and the Cabinet of St James's had agreed to ſend a plenipotentiary to a congreſs to be held for that purpoſe, at any place agreed upon by the courts of Vienna and Paris. The Conſul however would not admit a Britiſh plenipotentiary unleſs a naval armiſtice ſhould be previouſly agreed to between France and England; and becauſe the court of London rejected a propoſal unprecedented, and in itſelf ſo very unreaſonable that even he who made it did not expect it to be agreed to,

438 Moreau received orders to recommence hoſtilities.

Hoſtilities renewed between the Auſtrians and French.

The Auſtrian army was now under the command of Generals, whoſe names had ſcarcely reached beyond their own country, and who ſoon ſhewed that they had little experience in the art of war. While Moreau was meditating the plan of his winter campaign, the right wing of his army was attacked by the Auſtrians with ſuch ſpirit and ſucceſs, as ſeemed to reduce him to the neceſſity of acting on the defenſive; and he would have been completely ruined, had Klenau made a temperate uſe of his victory. This, however, he did not; for, elated with his good fortune, he quitted his ſtrong poſition on the Inn, and attacking his vigilant and able antagoniſt near the village of Hohenlinden, was completely defeated, with the loſs of 80 pieces of cannon, 200 caiſſons, and, if any credit be due to the French official papers, no leſs than 10,000 priſoners, beſides an immenſe number left dead on the field of battle.

Moreau, without ſuffering the Auſtrian commander to rally his ſcattered forces, marched directly to the Inn, which he croſſed on the 9th of December 1800; and driving his enemies before him, ſtruck the court of Vienna with terror and diſmay. Prince Charles was ſuddenly recalled to the command of the army; and after making one fruitleſs effort to retrieve the affairs, not only of Auſtria, but of Europe, he propoſed an armiſtice, which on the 27th of December the French general was glad to accept, on condition that peace ſhould, without farther delay, follow this third ceſſation of hoſtilities. Could the Archduke have depended on his army, weakened as it was, this armiſtice would probably not have taken place; for the poſition held by Moreau was tremendous. He had plunged himſelf into the very heart of Auſtria, leaving behind him, on his right, the Tyrol, filled with troops to the amount of 30,000; beſides the diviſions of Klenau, Simbſchen, and Riſkenfield, with the legion of Bohemia, forming more than 50,000, on his left. But the ſpirit of the Auſtrians was broken, and the principles of too many of their officers were corrupted.

This armiſtice was followed by a treaty of peace concluded at Luneville on the 9th of February 1801, between the Emperor in his own name and in the name of the Germanic body, and the Firſt Conſul of the French republic in the name of the French people. The terms of this peace differed little from thoſe of the treaty of Campo Formio; only, the Emperor bound himſelf to cede to the Duke of Modena, as an indemnity for the countries which that prince had loſt in Italy, the Briſgau, and to find in the Germanic empire indemnities to all thoſe princes who, by the fate of war, had been deprived of their dominions; while the Grand Duke of Tuſcany was to renounce, for himſelf and his ſucceſſors, the Grand Dukedom, and that part of the Iſle of Elbé which depends on it, in full ſovereignty to the infant Duke of Parma, obtaining a full and complete indemnity in the empire! On the juſtice or injuſtice of ſuch a treaty we make no remarks: the facts will ſpeak for themſelves to every one of our readers.

French Revolution, 1801.

439 Peace between Auſtria and France;

440 Between France and Naples;

On the 28th of March a treaty of peace was likewiſe concluded between the King of the two Sicilies and the French republic; in which his Sicilian Majeſty bound himſelf to ſhut all the ports of Naples and Sicily againſt Turkiſh and Engliſh ſhips, as well merchantmen as ſhips of war, till the concluſion of a definitive treaty of peace between thoſe two powers and the French republic, and likewiſe between England and the powers of the north. He renounced likewiſe, for himſelf and his ſucceſſors, Porto Longano in the Iſle of Elbe, and every thing belonging to it in that iſland; together with the ſtates of the Preſides in Tuſcany, which, with the Principality of Piombino, he ceded to the French government, to be by it diſpoſed of at its pleaſure. In both theſe treaties the French plenipotentiaries took upon themſelves to act for the Batavian, Helvetic, Ligurian, and Ciſalpine republics, as if theſe ſtates were provinces of France.

Great Britain was now left to carry on the war without a ſingle ally but the Turks in Egypt and the Portugueſe in Europe; and theſe, inſtead of being able to lend her aid, contributed only to diminiſh her force by

441 dividing it. At the inſtigation of France, Spain had attacked Portugal, and conquered ſome of her provinces; but on the 6th of June a treaty of peace was concluded between thoſe two powers; by which the king of Spain reſtored all his conqueſts except the fortreſs of Olivenza with its territory and inhabitants from the Guardiana, which was henceforth to be the boundary on that ſide between the two kingdoms. On the other hand, the Prince Regent of Portugal and Algarva engaged to ſhut the ports of his whole territories againſt the ſhips of Great Britain, and to make good to his Catholic Majeſty all damages or injury which his ſubjects might have ſuſtained, during the war, from the Britiſh navy or the ſubjects of the Queen of Portugal, and for which indemnification could rightfully be claimed.

And between Spain and Portugal.

The Conſul having made peace with all his other enemies, menaced the kingdom of Great Britain with invaſion; and the people, or at leaſt part of them, were weak enough to be alarmed at his empty threats. To baniſh this panic from the public mind, Lord Nelſon was ſent to deſtroy the ſhipping and harbour of Boulogne. His ſucceſs was not equal to the goodneſs of his cauſe; but, on the 4th of Auguſt, he made ſuch an impreſſion on the enemy, as put an end to their dreams

French Revolution, 1801.

dreams of invaſion, and ſhewed the inhabitants of Britain that they were abler to annoy the French coaſt, than the Conſul and his myrmidons were to annoy their's. It was ſeen, too, about this time, that the ſpirit of the Britiſh navy was not attached excluſively to the hero of the Nile; for in the month of July rear-admiral Sir James Saumarez came up with a ſquadron of French and Spaniſh ſhips of war bound for Cadiz; and though their force was ſuperior to his own, he took one of them, and two others were burnt.

442 Negotiations between Britain and France.

Early in this ſummer negotiations had been entered into between the Britiſh and French courts for the reſtoration of peace to Europe. The diſſolution of the northern confederacy had ſhewn the ambitious Conſul that he could not annihilate the Engliſh trade, and that of courſe all the treaties which he had made for the excluſion of our ſhips from the ports of neutral powers were of no validity. His heart, however, was ſet upon the retention of Egypt, which every maxim of juſtice as well as of ſound policy impelled the cabinet of St James's to wreſt from his gripe. The negotiation was therefore protracted from day to day, till intelligence arrived at London and Paris of the complete conqueſt of that country.

On the death of Sir Ralph Abercromby, the command of the Britiſh forces devolved upon General Hutchinſon, who ſoon ſhewed that he was not unworthy to ſucceed ſo great a man, and who, as he was probably acquainted with the plan of operations formed by his deceaſed friend, ſeems to have been actuated by the ſame ſpirit. Marching with the main body of the army towards Alexandria, which was occupied by Menou, he ſent Colonel Spencer with a diviſion of the Britiſh forces, aided by a body of Turks, to attack Roſetta; which ſoon ſurrendered to the Britiſh commander.

443 Conqueſt of Egypt.

The ſurrender of Cairo followed, on the 22d of June, on terms favourable to the beſieged; and Menou, accepting of the ſame terms for Alexandria, the allies became maſters of the whole of Egypt, from which the French army, with its baggage, was to be tranſported, in ſhips of the allied powers, to the neareſt French ports in the Mediterranean. The intelligence of theſe events forwarded the negociation for peace between Great Britain and France; and on the 1ſt of October, the preliminary articles were ſigned at London by Lord Hawkeſbury on the part of his Britannic Majeſty, and M. Otto on that of the French Republic. By this treaty Great Britain agreed to the reſtoration of all the conqueſts ſhe had made during the war; the iſland of Trinidad and the Dutch poſſeſſions in Ceylon excepted: The French Republic agreed to the reſtitution of nothing! The Cape of Good Hope, though reſtored to the Batavian Republic, was to remain a free port to the other contracting parties, who were to enjoy there the ſame advantages of trade with the Dutch themſelves. The iſland of Malta was to be reſtored to the Knights of the order of St John of Jeruſalem; its independence was to be guaranteed by Great Britain, Auſtria, Ruſſia, Pruſſia, and France; and it was to be evacuated by the Britiſh forces as ſoon as it ſhould be taken poſſeſſion of by the Knights, and garriſoned by 2000 Neapolitan troops. Egypt was to be reſtored to the Ottoman Porte; and the territory of Portugal was to be maintained in its integrity, with the exception of the fortreſſes and its dependencies, ceded by the Prince Regent to the King of Spain. The French were to evacuate the kingdom of Naples, and the Roman ſtates—the Britiſh, Porto Ferrajo, and all the ports and iſlands that they occupied in the Mediterranean and Adriatic. The republic of the Seven Iſlands was recogniſed by France; the fiſhery on the banks of Newfoundland was eſtabliſhed on its former footing; and, finally, plenipotentiaries were to repair to Amiens, and there proceed to the formation of a definitive treaty in concert with the allies of the contracting parties.

French Revolution, 1802.

444 Treaty of Amiens.

That treaty was concluded on the 22d of March 1802 by the plenipotentiary of his Britannic Majeſty on the one part, and the plenipotentiaries of the Catholic King and the French and Batavian Republics on the other; but it differs in ſome particulars, as well from the letter as from the ſpirit of the preliminaries agreed on and ſubſcribed by Lord Hawkeſbury and M. Otto. The territorial poſſeſſions of the Queen of Portugal were *not* maintained in their integrity; for the boundaries of French and Portugueſe Guiana are, by the ſeventh article of the definitive treaty, fixed by the river Arowary; the free navigation of which gives to France the abſolute command of all her faithful Majeſty's dominions in that part of the world. The French troops were indeed to be withdrawn from the kingdom of Naples and the Roman ſtates; but during the interval which paſſed from the ſigning of the preliminaries to the concluſion of the definitive treaty, the firſt Conſul took poſſeſſion of the iſland of Elba; and having got himſelf elected preſident of the Italian republic, which he had lately formed, he has ſecured a pretext for pouring French troops into Italy whenever his ambition may impel him to ſuch a meaſure. In the view of abſtract juſtice, ſuch deviations from the ſpirit of the preliminaries, agreed to at London by the accredited miniſter of the French Republic, would have been a ſufficient reaſon for breaking off the treaty; but the Britiſh government, ſtudying immediate expediency and the temper of the people, directed the Marquis Cornwallis to ſign it. Thus was the French revolution completed, and the republic acknowledged by all Europe.

445 French revolution completed.

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446 Errors in the former part of the article corrected.

We cannot, however, diſmiſs the momentous ſubject without correcting ſome errors into which we fell in the account of the riſe and progreſs of this revolution which was publiſhed in the *Encyclopædia*. We do not conſider theſe errors as diſgraceful to ourſelves; for in the midſt of commotions which have convulſed all Europe, it is hardly poſſible to arrive at the truth. When time ſhall have cooled the paſſions of men, and annihilated the parties which now divide the nation, the calm voice of Truth may be everywhere heard; but when the article referred to was written, the ears of every man was ſtunned with the clamour of faction.

So ſenſible of this are the editors of the only impartial periodical hiſtory * which we have, that they venture not to publiſh their volumes till ſeveral years have elapſed from the era of the tranſactions which theſe volumes record; whilſt their rivals—the panders of faction—ſeize the earlieſt opportunities of obtruding their partial ſtatements and falſe reaſonings on the public mind.

* *Old Annual Regiſter.*

It cannot be ſuppoſed that one or two men, ſuperintending the publication of a work ſo extenſive, and treating of ſubjects ſo various, as ours, have leiſure or opportunity to examine with much attention the correſpondence of ambaſſadors, or to expiſcate truth from the contradictory publications of the day. We are therefore

French Revolution.

therefore obliged to draw our materials from ſuch works as profeſs to give a ſummary, but impartial, detail of what is acting on the theatre of the world; and by theſe works we have often been miſled. For the firſt error, however, which we ſhall notice in our former account of the riſe of the revolution, we cannot plead even this excuſe. We ought to have known, that the French clergy and French nobleſſe were not exempted from the payment of taxes; and, of courſe, we ought not to have aſſigned ſuch exemption as one of the cauſes of the REVOLUTION. See that article, *Encycl.* n 8. and 9.

447 First error.

By a writer, to whoſe patriotic exertions this country is deeply indebted, it has been proved, with a force of argument which precludes all poſſibility of reply, that the exemption from taxes ſo loudly complained of was very trifling, that it was not confined to the nobility and clergy, and that it did not extend over the whole kingdom of France. "The *vingtiemes*, which may be conſidered as an impoſt merely territorial, was paid alike by the nobility and the *tiers-etat*. A great part of the clergy was indeed exempted; but their contributions, under a different form, conſtituted an ample equivalent. The duties upon the different articles of conſumption were of courſe paid by all the conſumers, except that in the *pays d'etat*, ſuch as Artois and Brittany; the two firſt orders were exempted from paying the tax upon liquors. But theſe exemptions cannot be deemed very important, when it is known, that in the province of Artois they did not exceed 800 guineas annually, even including the exemptions enjoyed by the privileged members of the *tiers-etat*." The Britiſh officers ſerving on board ſhips of war are exempted from the taxes paid by the other members of the ſtate on wine; and we believe no good ſubject has ever murmured at that exemption. The French nobility were ſubject to the pole-tax.

"Of the *teilles*, the impoſt from which it has been falſely aſſerted that the nobility and clergy enjoyed a total exemption, there were two ſpecies; the one *perſonal*, the other *real*. In one part of the kingdom, the right of exemption was annexed to the property; in the other, to the quality of the proprietor. In the firſt caſe, the privilege was enjoyed by every claſs of perſons, by the tenants as well as the proprietor of a fief; whilſt the gentleman, whoſe eſtate was holden by a different tenure, was obliged to pay the tax. In thoſe provinces where the other cuſtom obtained, the exemption was confined to a certain extent of property, and to *that* only while it continued in the actual occupation of the privileged perſon; but as it very ſeldom happened that the French nobility kept any land in their own hands, and as the tax payable by the farmers was of courſe deducted from the rent, the *teilles* was, in this caſe, ultimately paid by the landlord. The ſame obſervations apply, with ſtill greater force, to the clergy, who always let their eſtates."

In a word, it appears from a formal declaration made by M. Necker to the Conſtituent Aſſembly, that all the pecuniary exemptions enjoyed by the privileged claſſes did not exceed L. 292,000; that the exemptions appertaining to the privileged perſons of the *tiers-etat* amounted to one half of that ſum; and the *drôits de controle*, or duty impoſed upon public deeds, and the high capitation tax (proportioned to their rank), paid by the nobility and clergy, made ample amends to the revenue for the partial exemptions which they enjoyed from other taxes. So far, indeed, were the *tiers-etat* from murmuring at the exemptions of the privileged orders, that, previous to the illuminiſm of the 18th century, they diſplayed, at every convention of the ſtates-general, the greateſt anxiety to maintain the rights of the nobility and clergy; and humbly ſupplicated their ſovereign to ſuffer no invaſion thereof, but to reſpect their franchiſes and immunities *.

We muſt likewiſe acknowledge, that in n° 11. of our article REVOLUTION, we have drawn a very overcharged picture of the miſeries and oppreſſion of the French peaſants under the old government. It is indeed true that they were obliged to ſerve in the militia, the eſtabliſhment of which was conducted in France nearly on the ſame principles as it is in England. The men were called out by ballot only for a few days in the year during peace, when they received regular pay; but if a militia forms the beſt conſtitutional defence of a ſtate, this ſurely ought not to have been conſidered as a grievance, eſpecially ſince married men were exempted from the ſervice. The nobility, too, were exempted from the riſk of being drawn, for the beſt of all reaſons—becauſe moſt of them had commiſſions in the regulars, and becauſe ſuch as had not were engaged in profeſſions, which rendered it impoſſible for them to ſerve in the militia. In France, as elſewhere, the peaſants would no doubt be averſe from this ſervice, and might look perhaps with an anxious eye to the ſuppoſed immunities of their privileged ſuperiors; but if mirth, good humour, and ſocial eaſe, may be conſidered as ſymptoms of felicity and content, theſe men ſurely were not miſerable; for theſe ſymptoms never appeared in any people ſo ſtrong as among the French peaſants. They were indeed liable to be called out by the intendants of the provinces to work a certain number of days every year on the public roads; but to this ſpecies of oppreſſion, if ſuch it muſt be called, the Scotch peaſants are liable, and were ſtill more ſo than at preſent, during that period when our parliamentary orators declare that the inhabitants of Britain enjoyed as much freedom as is conſiſtent with the public tranquillity. It ought to be remembered, too, that Louis XVI. whoſe higheſt gratification ſeems to have conſiſted in contributing to the eaſe and welfare of his ſubjects, thought he ſaw the neceſſity of aboliſhing the cuſtom of the *corvée*, and had made conſiderable advances towards the accompliſhment of that object ſome years before the commencement of the revolution.

448 Second error.

449 The French monarch not deſpotic.

That the French monarch was deſpotic; that no man in the kingdom was ſafe; that nothing was unknown to the jealous inquiſition of the police; and that every man was liable, when he leaſt expected it, to be ſeized by *lettres de cachet*, and ſhut up in the gloomy chambers of the Baſtile—has long been common language in England, and language which we muſt confeſs that we have adopted (REVOLUTION, n° 12.) without due limitations. The French government was certainly not ſo free as that of Britain; but he who underſtood it better than we do, and whoſe writings betray no attachment to arbitrary power, expreſsly diſtinguiſhes between it and *deſpotiſm*. "If (ſays Monteſquieu) France has, for two or three centuries paſt, inceſſantly augmented her power, ſuch augmentation muſt not be aſcribed to fortune, *but to the excellence of her laws* †."

* See *Giſford's Letter to the Earl of Lauderdale*, 2d ed.

† *De l'Eſprit des Loix*, liv. 20. c. 20.

This, surely, is not the language of a man who thought himself governed by an arbitrary tyrant whose *caprice* is the law; nor will it be said to be the language of one who was either afraid to speak the truth or not master of his subject.

450 No change of the old constitution wished by the people of France.

The instructions of all the different orders to their representatives, before the fatal meeting of the States General under the unfortunate Louis, are drawn up in language similar to that of this illustrious magistrate, and furnish a complete proof that they knew themselves to be safe under the government of their monarchs. "The constitution of the state (say the clergy) results from the *fundamental laws*, by which the respective *rights* of the *king* and of the *nation are ascertained*, and from which not the smallest deviation can be made. The first of these laws is, that the government of France is purely monarchical. The nation must preserve inviolate the form of its government, which it acknowledges to be a *pure monarchy regulated by the laws*; and such it will have it to remain."

On the 28th of November 1788, in a general committee of the nobles assembled at Versailles, the Prince of Conti delivered a note to the president, which was sanctioned by the concurrence of most of the other princes of the blood, and was supposed to speak the general sense of the nobility; in which it was insisted, that the *proscription of all* NEW SYSTEMS *was necessary* to insure the stability of the throne, of *the laws*, and of *order*; and that the constitution, *with the ancient forms*, should be preserved entire. In their instructions to their representatives, they insist that it shall be expressly and solemnly proclaimed, that the constitution of the French empire is such, that its government is, and must remain, monarchical; that the king, as supreme chief of the French, is only subordinate to the fundamental law of the kingdom, according to which the constitution must be established on the sacred and immutable principles of monarchy, tempered by the laws; and this form of government cannot be replaced by any other constitution.

"Let our deputies (says the third estate), before they attend to any other object, assist in giving to France a truly monarchical constitution, which must invariably fix the *rights* of the *king* and of the *nation*. Let it be declared, that the monarchical is the only form of government admissible in France; and that in the *king alone*, as chief of the nation, is vested the power of *governing according to the laws*." Is this the language of men groaning under the iron rod of despotism, or wishing to reduce the power of the crown?

Even after the power of the crown was almost annihilated, and the order of nobility done away, so far were these innovations from being acceptable to the enlightened part of the French nation, that in many departments of the kingdom they excited open insurrections, whilst the members of all the provincial parliaments opposed them with unanswerable arguments furnished by the law. The chamber of vacation of the parliament of Toulouse, in particular, protested against the proceedings of the States General, because the deputies, who were empowered only to put an end to the ruinous state of the finances, could not change the constitution of the state without violating their instructions, and the faith sworn to their constituents *.

* See the protest at large in *Bertrand's Memoirs*, vol. iii. c. 13.

That *lettres de cachet* were liable to abuse, and that occasionally they were grossly abused, is certain. The use of them ought therefore to have been either annulled, or, which would have been infinitely better, subjected to such rules as should prevent all danger from them to the real liberties of the people; for the government would be of no use whatever which should possess no power capable of being abused by despotism. Yet after all the noise that has been made about *lettres de cachet*, it is but justice to observe, that in the towers of the Bastile, when it was taken by the mob, were found no more than seven prisoners; of whom four were confined for forgery; one was confined at the request of his family on charges of the most serious nature; and two were so deranged that they were sent next day, by those philanthropists who had taken them out of comfortable chambers, to the mad house! That the chambers of the Bastile were as comfortable as the chambers of a prison could be, we are assured by M. Bertrande de Moleville, who can be under no inducement to deceive the British public, and whose opportunities of discovering the truth were such as no man will call in question.

451 Lettres de cachet.

452 Blunder of Necker.

In our account of the opening of the States General, we have expressed too much deference to the character of M. Necker. To that man's irresolute, if not treacherous, conduct, may, with truth, be attributed all the subsequent miseries of France. It was about the mode of verifying their powers that the three orders of the state first differed; but that mode should have been defined by the ministry in the letters sent to the different bailiwicks for the convention of the states. Even this omission might have been repaired after the arrival of the deputies at Versailles; for none of them should have been admitted into the hall of the states, far less should the king have met them there, till the Council had been satisfied of their being duly elected. Had either of these cautions been observed, the *tiers-etat* never could have got the ascendant over the other two orders, and the business of the nation would have been conducted as formerly in three different chambers. M. Necker's rejection of Mirabeau's advances shewed him to be very ill qualified to conduct the helm of affairs at such a crisis; and his absenting himself from the royal session, a measure which he had advised, betrayed the utmost ingratitude to his gracious master.

In our account of the royal session, we were led into a mistake, which calls loudly for correction. The circumstances of that session were very different from what they appeared to us when we wrote n° 24. and 25. of the article REVOLUTION. The royal session was proclaimed in consequence of the violent usurpations of the *tiers-etat*, and the irreconcileable differences which subsisted between that body and the two higher orders; and so far is it from being true that the president and members of the third state found their hall *unexpectedly* surrounded by a detachment of guards, that their sittings were only *suspended*, for the best of all reasons, with those of the other orders. To be convinced of this, we need but to attend to the following proclamation which was made by the heralds, on the 20th of June, between seven and eight o'clock in the morning, in the streets and cross-ways of Versailles: 453 Royal Session.

"June 20th. (By order of the King.) The King having resolved to hold a royal sitting in the States General, on Monday next the 22d of June, the preparations to be made in the three halls used by the assemblies

French Revolution.

blies of the orders, make it neceſſary that thoſe aſſemblies ſhould be ſuſpended until after the ſaid ſitting. His Majeſty will give notice, by another proclamation, of the hour of his going to the Aſſembly of the States on Monday."

M. Bailly, the preſident of the *tiers-etat*, had been made acquainted with the object of this proclamation, by a private letter which was ſent to him by the Marquis de Brezé at ſeven o'clock in the morning; and to which he replied, "that having received no orders from the King, and the aſſembly having been announced for eight o'clock, he ſhould attend where his duty called him."

He repaired, accompanied by a great number of the members of the *tiers-etat*, to the door of the hall of the States, demanded admiſſion; and on being refuſed by the officer on guard, according to his orders, with which he acquainted him, he declared that he proteſted againſt ſuch orders, and that he ſhould give a report of them to the Aſſembly. To do this he had not far to go, as three-fourths of the deputies of the *tiers-etat*

454 Factious insolence of the assembly.

were already collected round him, or in the avenue leading to the palace. There it was that, ſurrounded by an immenſe crowd of people, they declaimed in the moſt violent manner againſt this pretended act of deſpotiſm. "The National Aſſembly is to be diſſolved (ſaid they), and the country to be plunged into the horrors of a civil war. *Want* reigns every where; every where the people ſee *famine* ſtaring them in the face. This we were about to put an *end to*, by rending the veil which covers the manœuvres of the monopoliſts, the engroſſers, and the whole tribe of miſcreants. The Louiſes XI. and XIII. the Richelieus, the Mazarins, the Briennes, attacked with their deſpotiſm only individuals or ſmall bodies; but here it is the whole nation that is made the ſport of the whims of a deſpotic miniſtry. "Let us meet upon the *Place d'Armes* (ſaid one of thoſe orators); there we ſhall recal ſome of the nobleſt days of our hiſtory, *the National Aſſemblies of the field of May*." "Let us aſſemble in the gallery of the palace (ſaid another); there we ſhall preſent a new ſight, by ſpeaking the language of liberty, in that corrupt hall, where a little while ſince the head of him who ſhould have uttered that ſacred word would have been devoted to the executioner.—"No, no (ſaid a third), let us go to Marli, and hold our ſitting on the Terrace:—let the King hear us; he will come from his palace, and will have nothing more to do than to place himſelf in the midſt of his people to hold the royal ſitting."

At the concluſion of theſe declamations, the ſole object of which was to alarm and exaſperate the people, the Aſſembly decided upon transferring their ſitting to the Tennis-court, in the ſtreet called *Rue du Vieux Verſailles*. There M. Bailly read the letter which he had received from M. de Brezé, and his anſwer to it; which he had ſcarcely done, when a ſecond letter from M. de Brezé was put into his hands, the contents of which were as follows:

"It was by the King's poſitive order, Sir, that I did myſelf the honour of writing to you this morning, to acquaint you that, his Majeſty purpoſing to hold a royal ſitting on Monday, and ſome preparations being requiſite in the three halls of the aſſemblies of the orders, it was his intention that no perſon ſhould be admitted into them, and that the ſittings ſhould be ſuſpended till after that to be held by his Majeſty."

French Revolution.

In this there was ſurely no marked diſrepect to the repreſentatives of the people; but ſuch notions were countenanced by M. Necker, who appears indeed, on this occaſion, to have been in cloſe compact with the leaders of the mob. The popular violence that was employed to compel the majority of the clergy to join the *tiers-etat* is well known; and we have, in *Bertrand's Annals of the Revolution*, what amounts to evidence almoſt *legal*, and quite ſufficient to enforce conviction, that Necker directed that violence.

In our account of the commotions which were excited in Paris on the firſt diſmiſſion of that miniſter and his baniſhment from the kingdom, we have been led by our democratic journaliſts to give circulation to a groſs calumny publiſhed by them againſt the Prince de Lambeſc. (See Revolution, n° 36. and 37.) The truth, which is ſo much diſguiſed in theſe two numbers, is as follows:

455 Conduct of the Prince de Lambeſc vindicated.

"A detachment of the Royal Allemand, ſent to diſperſe the mob which was patrolling the ſtreets in proceſſion with the buſts of Necker and the infamous Orleans, received a volley from the French guards as they were paſſing their quarters on the *Chauſſée d'Antin*, ſtopped to return it, and continued their march without quickening their pace. There were ſome ſoldiers killed and wounded on both ſides, but fewer of the regiment of Royal Allemand than on that of the French guards.

"The detachment marched to the place Louis XV. and there found a body of dragoons who had been diſperſing the proceſſion. The two buſts were broken to pieces; and the populace in their fright taking refuge in the garden of the Thuilleries, the Prince de Lambeſc purſued them thither, at the head of the detachment of Royal Allemand, according to the orders which he received. This ſmall troop coming up to the head of the *Pont-tournant* (or turning bridge), at the extremity of the garden, found a kind of barricade, haſtily formed by chairs heaped upon one another: while they were removing this obſtacle, they received a ſhower of ſtones, broken chairs, and bottles, from the two terraces, between which the Prince de Lambeſc drew up his troop, keeping conſtantly at their head. Some guns and piſtols were diſcharged at them, which did no hurt; but ſeveral of the troopers were much bruiſed by the things that had been thrown at them, and an officer was ſeverely wounded by a ſtone.

"The Prince de Lambeſc, keeping at ſix paces from the bridge, oppoſed only a ſteady front to the aggreſſions of the populace. Seeing that this poſt became untenable, and that it was impoſſible for him any longer to reſtrain his troopers from repelling force by force, he gave the order for retreating out of the garden. At the ſame inſtant a cry was heard from all ſides of, *turn the bridge, turn the bridge*; and ſome perſons, in conſequence, ran and began to do it. The Prince de Lambeſc, juſtly fearing that a moſt bloody carnage would be the inevitable conſequence of it, ordered ſome piſtols to be fired in the air towards the bridge, to awe thoſe who were ſtriving to turn it. As the report of this volley did not deter them, he rode up himſelf, and with his ſabre ſtruck one of thoſe who were working hardeſt. The man ran off; and the Prince paſſing the bridge with

French Revolution.

with his detachment into the Place Louis XV. drew up near the Statue, and being foon joined by the Swifs regiment of Chateauvieux, took his poft with this force near the *Gardemeuble*, where he remained fome time, having placed the infantry before him. At ten at night part of the troops were difmiffed to their quarters, and the reft fent to Verfailles." Thefe facts being all judicially confirmed, prove how much the Prince de Lambefc's conduct was calumniated by thofe journalifts whofe detail we rafhly adopted.

456 True account of the taking of the Baftile,

In our account of the taking of the Baftile, mifled by our treacherous guides, the journalifts, we have greatly magnified the military fkill and prowefs of the affailants. That celebrated fortrefs was defended by a garrifon confifting of no more than 114 men, of whom 82 were invalids. It was attacked by 30,000 men and women, armed with mufkets and pikes, and furnifhed with a train of artillery which they had found at the *Hotel des Invalids*, given up to them by the timidity of the governor. Even this multitude would have been quickly repulfed from the Baftile, if the governor of that ftate-prifon, who had received no orders from the court, had been lefs reluctant to fhed the blood of his rebellious countrymen; for the Parifian mob had then difplayed nothing of determined courage. A few difcharges of mufquetry, and one of canifter fhot from a fingle cannon, had thrown them into confufion, and made them fkulk behind the walls, when the ill-timed humanity of the governor made him enter into a treaty with the rebels, ftipulating only that the garrifon fhould not be maffacred. How the ftipulation was obferved with refpect to the governor himfelf, we have faithfully related; but we were miftaken when we faid that the "French guards fucceeded in procuring the fafety of the garrifon." The guards, with the utmoft difficulty, faved indeed fome of them, but moft of the invalds remaining in the courts of the caftle were put to death in the moft mercilefs manner.

457 And of the murder of M. de Fleffelles.

Our account of the murder of M. de Fleffelles (n° 40.) appears likewife to be very incorrect. This man was prefident of the affembly of Electors at Paris (See Revolution, n° 45.), and had not quitted the *Hotel de Ville*, where their rebellious meetings were held, during the whole time of thefe dreadful commotions. He had even figned all their atrocious refolutions, but became fuddenly fufpected from the confternation which he manifefted at the fight of fo many horrors, and efpecially at the cruel and treacherous murder of the governor of the Baftile. The confequence was, that he was treacheroufly murdered himfelf by one of the villains compofing that affembly in which he prefided. "The electors (fays M. Bertrand de Molleville) hoped to extenuate the horror of this affaffination, by caufing it to be confidered as a natural and almoft lawful vengeance for a treachery, the proof of which they pretended to have. In fact, they declared, that when M. de Launay, the governor of the Baftile, was arrefted, a letter had been found in his pocket from M. de Fleffelles, containing this expreffion: 'I am amufing the Parifians with cockades and promifes; hold out till night, and you will receive a reinforcement.' But this fuppofed letter, which, had it exifted, they would not have failed to preferve very carefully, was never feen by any body; and I heard M. Bailly himfelf fay, in a vifit he paid me when he left the mayoralty, that he had no knowledge of it, and that it was not in his power to refer to any one who had told him that he had read it."

458 Ambition and cowardice of the Duke of Orleans.

In our account of the earlier tranfactions of the Revolution, we omitted to mention a very extraordinary inftance of ambition to which the Duke of Orleans was incited by Count Mirabeau, but which that unnatural monfter wanted courage to carry into effect. During the commotions which prevailed in the capital on the difmiffal of M. Necker from the miniftry, Orleans was perfuaded by Mirabeau to offer his fervices as mediator between the king and his rebellious fubjects; but to ftipulate, at the fame time, for his appointment to the high office of lieutenant-general of the kingdom as neceffary to give his mediation due weight with the rebels. The real object of the profligate Count, in this dangerous propofal, and which he did not deign even to conceal, was to pave the way for the infamous Duke ftepping into the throne of his relation and virtuous fovereign. He even went fo far as to compofe the fpeech with which Orleans was to addrefs the king on the occafion; but that coward, when he arrived at the palace, was fo embarraffed by the confcioufnefs of his own wicked defigns, that inftead of afking the office of lieutenant general, he only requefted permiffion to retire into England!! A requeft which was inftantly granted.

This brought upon him the contempt and indignation of Mirabeau; but ftill there was a party defirous of placing him on the throne. This we think evident from an atrocious fact mentioned in all the journals, and confirmed by M. Bertrand. "When the king, on his firft vifit to Paris (See n° 44.) had arrived at the *Champ Elifées*, three or four guns were fired at once. It was never known whence they proceeded; but it is certain that an unfortunate woman in the crowd, who was in the direction of his Majefty's carriage, was fhot at the time, and fell dead on the fpot." As the King's carriage held at the time exactly four perfons, M. Bertrand very naturally concludes that thefe four fhots, fired at once in its direction, had been ordered and paid for; and we are unwilling to believe that at that period of the revolution there was any party difpofed to *pay* for the murder of the fovereign but the Duke of Orleans and his infamous adherents. That he was equal to this wickednefs cannot be doubted, when it is known that legal evidence was afterwards produced that he, with fome other members of the Affembly, fecretly directed the infurrection of the 5th of October, and promoted the outrages of that and the fucceeding day by the diftribution of money and bread *.

459 M. Memmay vindicated.

We have faid (n° 48.), the origin of the report of a train of gunpowder being laid by M. de Memmay, to blow into the air a number of patriots, has never been well explained. It was proved judicially, that at the period when the feaft was given by M. Memmay to the inhabitants of Vefoul, he was fetting vines in a ftony foil, where he was often obliged to blow up the greater rocks. Some foldiers running through, and ferreting every where in the houfe and out-houfes, unfortunately took a candle to the dark corner where the barrel of gunpowder was lodged, and fet it on fire, in trying to fee if it contained wine. Thefe facts, reported and attefted in a memorial drawn up by M. Courvoifier, fo completely juftified M. de Memmay, that the Affembly

* *Bertrand's Annals*, vol. ii. ch. 13.

French Revolution.

bly could not avoid teftifying his innocence by a decree iffued the 4th of June.

460 The powers of the affembly in danger of being recalled by its conftituents.

In n° 70 we have faid that the National Affembly, after its removal from Verfailles to Paris, was in tolerable fecurity; but M. Bertrand has proved, by evidence the moft incontrovertible, that it did not think itfelf fecure; and that if the minifters had been capable of employing events to their own advantage, the powers of that factious body muft have been recalled by its own conftituents. The horrible outrages committed on the 5th and 6th of October had fhocked all France. The wanton confifcation of the property of the church, had demonftrated to every man of found judgment, that under the new order of things no property could be fecure: and by the defertion of its more virtuous and moderate members, the Affembly had become *a rump affembly*. It was therefore much alarmed when the intermediate commiffion of the ftates of Cambrefis entered, on the 9th of November, into a refolution, in which, confidering—"that certain decrees of the National Affembly are paving the way for the ruin of the kingdom, and the annihilation of religion; that if they have been able to place one fpecies of property at the difpofal of the nation, men of all kinds of property may expect the fame fate; they declare from this moment, the power of the deputies of Cambrefis to the National Affembly to be null and revoked." Had M. Necker and his colleagues had addrefs to get fimilar refolutions entered into at the fame time by the electors of all the bailiwicks of the kingdom, the Affembly muft have been diffolved, and France, even then, might have been faved; but thofe minifters were themfelves nothing more than the humble and docile agents of the Affembly.

461 True account of the red book,

There is no part of our former narrative more incorrect, or more likely to miflead the public, than our account of the *red-book* (n° 75). It is fuch, however, as was then current, without any addition or aggravation by us. The villains (K) who, in direct contradiction to their own folemn promife, as well as to every principle of honour, made part of that book public, had the impudence to affirm, that by the fuppreffion of the fuperfluous penfions regiftered in it, a faving would be made to the public *of near a fifth in the bulk of the expences of every year*. M. Bertrand, taking for granted the accuracy of their ftatements, for the exaggeration of which, however, he urges arguments more than plaufible, proves, if arithmetical calculation affords proof, that by the fuppreffion of fuch penfions as even *they* called fuperfluous, the faving in the bulk of the annual expences could not poffibly have amounted to more than *the two hundredth part!* It was not therefore without reafon that M. Necker, in anfwer to their publication, faid, "I know not whether the books of the finances of any fovereign in Europe can fhew a fimilar total."

462 And of the mutiny at Nancy.

Our account of the mutiny of the foldiers at Nancy (n° 83.) is very inaccurate. Far from being excited by the officers that mutiny was the natural confequence of the abfurd decrees of the Affembly; which having declared *all men equal*, and made it criminal to punifh difobedient foldiers in that fummary way, without which no armed force can be commanded, had completely diforganifed the army, and fubftituted for martial law patriotic exhortations, legiflative decrees, and the novel jurifdiction of municipalities. The foldiers knew their own ftrength, of which indeed they were continually informed by the friends of the revolution; and while they fhook off the authority of their military commanders, they laughed at the impotent decrees of the Affembly. At Nancy they had imprifoned two general officers, and committed other outrages of the moft ferious nature. It was the duty of the Marquis de Bouillé, as governor of the province, to reduce the infurgents by force, if force fhould be found neceffary; but he had accomplifhed his object without fhedding blood, and was congratulating the two liberated generals, and fome of the principal inhabitants, upon fo happy a termination of the affair, when the populace, and many foldiers who had not followed their colours, fired upon the troops under his command, and killed fifty or fixty men. The troops immediately returned the fire; and a great number of the rebellious mob and mutinous garrifon were of courfe put to the fword. That fuch able and firm conduct in Bouillé excited indignation among the Jacobins of Paris, is very probable; but even the king himfelf did not exprefs higher approbation of it than the National Affembly, who were duly fenfible that it faved themfelves from deftruction, which, had he failed in his enterprife, would have been inevitable. Three months afterwards, indeed, when the fabrication of counter-revolutionary plots became part of the daily bufinefs of this enlightened Affembly, fome cenfures were thrown by the Jacobins upon the Marquis's conduct on this occafion; and thofe cenfures were loudly applauded. 463

M. de Bouillé vindicated.

We have likewife been led, by our fallacious guides, to accufe this gallant officer (n° 91.) of having laid open the country to the inroads of foreign armies; and we have given an incorrect account of the king's flight from Paris. There is no evidence whatever for the truth of the charge againft the Marquis de Bouillé, and it is directly contrary to his general character. He was indeed a royalift, and would doubtlefs have cooperated with the Prince of Condé and the other emigrants in reftoring the king to his lawful authority; but he was likewife a Frenchman and a patriot in the beft fenfe of the word; and he would have died in defence of the rights and independence of his country. He certainly meant to protect the king in his journey from Paris to Montmedi, where it was to terminate; and he had ftationed troops of dragoons on the road for that purpofe; but the unfortunate Louis had delayed his journey a day longer than was agreed upon; and even when he fet out, neglected to fend couriers before him to warn the troops of his approach. He thus travelled unprotected; and the confequence was fuch as we have related. Yet the gallant Bouillé, tho' this journey was undertaken contrary to his advice, declared himfelf the author of it, in that letter in which he threatened the Affembly with vengeance of all Europe

(K) Thefe were the Marquis de Montcalm-Gozon, Baron Felix de Wimpfen, de Menou, Freteau L. M. de Lepeaux, the Abbé Expilly, Camus, Goupil de Prefeln, Gautier de Biauzat, Treilhard, Champeaux-Palafuc, and Cottin.

French Revolution. rope if they ſhould dare to touch a hair of the heads of the royal family.

464 Erroneous account in nº 90. corrected. In nº 90. we have moſt unaccountably ſaid, that the king was permitted to continue his journey to St Cloud. This is directly contrary to truth. The preſident, after hearing his complaint againſt thoſe who had prevented it, replied indeed in a ſpeech, containing ſome expreſſions of gratitude and affection, mixed with reflections on the refractory prieſts; but the Aſſembly determined nothing reſpecting the propriety of the journey. They did not even ſuffer a ſingle motion to be made on the ſubject; and threatened with impriſonment one of the members who propoſed to take it into conſideration! The king was therefore obliged to abandon this excurſion, though it was firſt undertaken from religious motives; and it was then that he ſeriouſly thought of attempting to elude the vigilance of his rebellious guards, and of taking up his reſidence at Montmedi.

465 Treaty of Pavia a forgery. In nº 96. we have publiſhed, with doubts indeed of its authenticity, what was called the *treaty of Pavia* and the *convention at Pilnitz*. The terms in which we introduced that ſcandalous fabrication to the notice of our readers, and the principles which we have uniformly avowed through the whole of this voluminous work, furniſh, we hope, ſufficient evidence that we could have no intention to deceive the public. Truth, however, demands of us to acknowledge, in the moſt explicit terms, that the pretended treaty of Pavia is not only a forgery, but a bungling forgery, defective in ſome of the moſt uſual diplomatic forms; and that the conferences at Pilnitz between the Emperor, the King of Pruſſia, and the Count d'Artois, related to objects very different from a partition of the French territories.

So early as the month of May 1791, a plan had been digeſted by the Emperor, the King of Pruſſia, and the King of Spain, with the concurrence of Louis XVI. for liberating that unfortunate Monarch from the confinement in which he was kept in his own capital. The means to be employed were a coalition among the principal powers on the continent to lead armies in every quarter to the borders of France. During the alarm which ſo menacing an appearance could not but excite in that kingdom, a declaration by the houſe of Bourbon, complaining of the cruel and iniquitous treatment of its head, was to be circulated through France, and to be immediately followed by the manifeſto of the combined powers. This, it was preſumed, would furniſh a ſufficient reaſon, even to the National Aſſembly, for the king's going to the frontiers, and placing himſelf at the head of the army; but if it ſhould not, petitions were to be procured from the army and the provinces, requeſting his preſence, as the only means left of preventing a civil as well as foreign war. Had this meaſure, which was partly ſuggeſted by Mirabeau and partly by Montmorin and Calonne, been ſteadily purſued, there can be little doubt but it would have proved completely ſucceſsful. It was defeated, however, by the king's ill concerted attempt to eſcape to Montmedi, and by a very imprudent and degrading letter which he was afterwards perſuaded to ſend to every foreign power.

466 Real convention at Pilnitz. At Pilnitz, where the Emperor and the King of Pruſſia met, on the 25th of Auguſt, to ſettle between themſelves ſome intereſts too delicate to be adjuſted by the uſual diplomatic modes, an agreement was entered into by them to ſupport the cauſe of the French princes, to liberate the king, and to ſave, if poſſible, the monarchy. They delivered, accordingly, to the Count d'Artois the following declaration:

"His Majeſty the Emperor, and his Majeſty the King of Pruſſia, having heard the deſires and the repreſentations of Monſieur and his Royal Highneſs the Count d'Artois, declare, conjointly, that they conſider the ſituation in which his Majeſty the King of France is at preſent placed, as a matter which concerns the intereſt of every ſovereign of Europe.—They hope that that intereſt will not fail to be acknowledged by the powers whoſe aſſiſtance is required; and that conſequently they will not refuſe to employ, in conjunction with their Majeſties, the moſt efficacious means, according to their abilities, to put the King of France in a ſituation to eſtabliſh, in perfect liberty, the foundations of a monarchical government, equally agreeable to the rights of ſovereigns and the welfare of the French: then, and in that caſe, their Majeſties are determined to act promptly and by mutual conſent, with the forces neceſſary to obtain the end propoſed by all of them. In the mean time they will give orders for their troops to be ready for actual ſervice.

"*Pilnitz, Auguſt* 27. 1791.

"Signed by the Emperor and the King of Pruſſia."

Such was the agreement entered into at Pilnitz, which was ſo groſsly miſrepreſented by the French Jacobins, and by their zealous partizans in this country. Had not Louis XVI. accepted the conſtitution ſimply and unconditionally, the conſequence of this convention might have been the ſaving of the French monarchy, and the preſervation of peace in Europe; but that acceptance, ſo little looked for by the high contracting powers, completely thwarted their meaſures for a time; and before their armies were put in motion, the monarchy was overturned, and the monarch a priſoner.

467 The French the aggreſſors in the war with Britain. In our account of the origin of the war between Great Britain and France (nº 147, 148.), we have proved, by evidence which to ourſelves appears irreſiſtible, that the French regicides were the aggreſſors, and that the Britiſh miniſtry did all that could be done, conſiſtently with the independence of their own country, to maintain the relations of amity between the two nations. That we have interpreted fairly that decree of the Convention by which this kingdom was forced into the war, is rendered incontrovertible by a ſubſequent decree on the 15th of December, by which their generals were ordered to regulate their conduct in the countries which their armies then occupied, or *might afterwards occupy*. In the preamble to this decree, they expreſsly declared, that *their principles would not permit them to acknowledge any of the inſtitutions militating againſt the ſovereignty of the people;* and the various articles exhibit a complete ſyſtem of demolition. They inſiſt on the immediate *ſuppreſſion of all exiſting authorities*, the *abolition of rank and privilege* of every deſcription, and the *ſuppreſſion of all exiſting impoſts*. Nay, theſe friends to freedom even declare, that they will treat as enemies *a whole nation* (un peuple entier) which ſhall preſume to *reject liberty and equality*, or enter into *a treaty with a prince or privileged caſts!*

It is worthy of remark, that *the very day* on which this decree, containing a ſyſtematic plan for diſorganizing all lawful governments, paſſed the Aſſembly, the provi-

French Revolution

provisional executive council wrote to their agent, Chauvelin, instructing him to disavow all hostile intentions on the part of France, and to proclaim her detestation of the idea of a war with England! Yet the same provisional council, in their comments on the 11th article of this decree, thus express themselves: "The right of natural defence, the duty of securing the preservation of our liberty, and the success of our arms, the universal interest of restoring to Europe a peace, *which she cannot obtain but by* THE ANNIHILATION OF THE DESPOTS *and their satellites*, every thing imposes on us the obligation of exercising all the *rigours of war*, and the *rights of conquest*, towards a people so fond of their chains, so obstinately wedded to their degradation, as to refuse to be restored to *their rights*, and who are the accomplices, not only *of their own despots*, but even of all the *crowned usurpers*, who divide among themselves the dominion of the earth and its inhabitants" That Britain is one of those countries which the Assembly thought their armies might afterwards occupy, and that the great majority of Britons were a people towards whom their principles obliged them to exercise all the rigours of war, and the rights of conquest, is evident from the following extract of a letter, written on the 31st of December 1792, by Monge, a member of the council, and minister of the marine to the sea-ports. "The King and his parliament mean to make war upon us. Will the *English republicans suffer it?* Already these free men shew their discontent, and the repugnance which they have to bear arms against *their brothers the French*. Well! we will fly to their succour. We will make a descent on the island; we will lodge there 50,000 *caps of liberty*; we will plant there *the sacred tree*; and we will stretch out our arms to our REPUBLICAN BRETHREN. *The tyranny of their government will be destroyed.*"

As these two decrees of November and December 1792 have never been repealed, and as their object is so plainly avowed in the commentaries of the executive council, and in this letter of the minister of marine, they would alone sufficiently authorise us to adopt as our own the following reflections of M. Bertrand de Moleville*. With these, as they give a concise but perspicuous view of the rise and progress of that revolution, or, to speak more correctly, that series of revolutions which has for seven long years oppressed, not France alone, but all Europe, we shall conclude this

468 long article.

Introduction to the *Annals of the French Revolution.*

Bertrand's view of the rise and progress of the revolution.

"Popular insurrections, and an army (says this able and useful writer), have hitherto been the usual means, or chief instruments, of every revolution; but those insurrections being of the most ignorant and unthinking class of the people, were always fomented by a certain number of factious men, devoted to, and dependent upon, some ambitious chief, daring, brave, of military talents, sole and absolute conductor of every step of the revolt, and master of all the means of the insurrection. In the hands of this chief, the soldiers, or people armed, were but machines, which he set in motion or restrained according to his pleasure, and of which he always made use to put an end to revolutionary disorders and crimes, as soon as the object of the revolution was gained. So Cæsar and Cromwell, after they had usurped the supreme power, lost no time in securing it to themselves, by placing it on the basis of a wise and well-regulated government; and they employed, in quelling the troubles that had favoured their usurpation, those very legions, that same army, which they had used to excite them.

"This was not the case in France: there, the revolution, or rather the first of those it experienced, and of which the others were the inevitable consequence, was not, whatever be supposed, the result of a conspiracy, or preconcerted plan, to overturn the throne, or to place an usurper upon it. It was unexpectedly engendered by a commixture of weakness, ignorance, negligence, and numberless errors in the government. The States General, however imprudent their convocation may have been, would have produced only useful reforms, if they had found the limits of their power marked out by a hand sufficiently firm to have kept them within that extent. It was, however, but too evident that, even before their opening, they were dreaded, and that consequently they might attempt whatever they pleased. From that time, under the name of *Clubs*, various associations and factions sprang up; some more violent than others, but all tending to the subversion of the existing government, without agreeing upon the form of that which was to be substituted: and at that juncture also the projects of the faction, whose views were to have the Duke of Orleans appointed lieutenant-general of the kingdom, began to appear.

"This faction, or more properly this conspiracy, was indeed of the same nature as those that had produced all former revolutions, and might have been attended with the same consequences, had the Duke of Orleans been possessed of that energy of character, that bravery and daring spirit, requisite in the leader of a party. The people had already declared in his favour, and he might very easily have corrupted and brought over a great part of the army, had he been equal to the command of it: but, on the very first occasion of personal risk, he discovered such cowardice and meanness, that he defeated his own conspiracy, and convinced all those who had entered into it, that it was impossible to continue the revolution, either in his favour or in conjunction with him. The enthusiasm the people had felt for him ended with the efforts of those who had excited it.

"Mr Necker, whom the multitude had associated with him in their homage, still preserved for some time his adorers, and that little cabal which was for ever exalting him to the skies. But as he was inferior even to the Duke of Orleans in military talents and dispositions, he was as little calculated to be the leader of a revolution, or of a great conspiracy: for which reason his panegyrists then confined themselves in their pamphlets and placards, with which the capital was overrun, to insinuating that the only means of saving the state was to declare Mr Necker *Dictator;* or at least to confer upon him, under some title more consistent with the monarchy, the authority and powers attached to that republican office. In fact, if after his dismission, in the month of July 1789, he had dared to make this a condition of his return to the ministry, it is more than probable that the king would have been under the necessity of agreeing to it, and perhaps of re-establishing in his person the office of mayor of the palace. At that moment he might have demanded any thing: eight days later, he might have been refused every thing; and

French Revolution.

and very ſoon after, he was reduced to ſneak out of the kingdom, in order to eſcape the effects of the general contempt and cenſure which he had brought upon himſelf.

" General La Fayette, who then commanded the Pariſian National Guard, gathered the wrecks of all this popularity, and might have turned them to the greateſt advantage, if he had poſſeſſed ' that reſolute character and heroic judgment' of which Cardinal de Retz ſpeaks, and ' which ſerves to diſtinguiſh what is truly honourable and uſeful from what is only extraordinary, and what is extraordinary from what is impoſſible.' With the genius, talents, and ambition of Cromwell, he might have gone as great a length; with a leſs criminal ambition, he might at leaſt have made himſelf maſter of the revolution, and have directed it at his pleaſure: in a word, he might have ſecured the triumph of whatever party he ſhould have declared himſelf the leader. But as unfit for ſupporting the character of Monk as that of Cromwell, he ſoon betrayed the ſecret of his incapacity to all the world, and was diſtinguiſhed in the crowd of conſtitutional ringleaders only by his three-coloured plume, his epaulets, white horſe, and famous ſaying— ' Inſurrection is the moſt ſacred of duties when oppreſſion is at its height.'

" The revolution, at the period when the faction that had begun it for the Duke of Orleans became ſenſible that he was too much a coward to be the leader of it, and when La Fayette diſcovered his inability to conduct it, was too far advanced to recede or to ſtop; and it continued its progreſs, but in a line that no other revolution had taken, viz. without a military chief, without the intervention of the army, and to gain triumphs, not for any ambitious conſpirator, but for political and moral innovations of the moſt dangerous nature; the moſt ſuited to miſlead the multitude, incapable of comprehending them, and to let looſe all the paſſions. The more violent combined to deſtroy every thing; and their fatal coalition gave birth to Jacobiniſm, that terrible monſter till then unknown, and till now not ſufficiently unmaſked. This monſter took upon itſelf alone to carry on the revolution; it directed, it executed, all the operations of it, all the exploſions, all the outrages: it every where appointed the moſt active leaders, and, as inſtruments, employed the profligates of every country. Its power far ſurpaſſed that which has been attributed to the inquiſition, and other fiery tribunals, by thoſe who have ſpoken of them with the greateſt exaggeration. Its centre was at Paris; and its rays, formed by particular clubs in every town, in every little borough, overſpread the whole ſurface of the kingdom. The conſtant correſpondence kept up between thoſe clubs and that of the capital; or, to uſe their own expreſſion, *des Sociétés populaires affiliées avec la Société mere*—' between the affiliated popular Societies and the parent Society,' was as ſecret and as ſpeedy as that of free-maſons. In a word, the Jacobin clubs had prevailed in cauſing themſelves to be looked up to as the real national repreſentation. Under that pretence they cenſured all the authorities in the moſt imperious manner; and whenever their denunciations, petitions, or addreſſes, failed to produce an immediate effect, they gained their point by having recourſe to inſurrection, aſſaſſination, and fire. While Jacobiniſm thus ſubjected all France to its controul, an immenſe number of emiſſaries propagated its doctrines among foreign nations, and prepared new conqueſts for it.

French Revolution.

" The National Aſſembly, the capital, indeed we may ſay all France, was divided into three very diſtinct parties. The moſt conſiderable in number, but unhappily the weakeſt through a deficiency of plan and reſolution, was the party purely Royal: it was adverſe to every kind of Revolution, and was ſolely deſirous of ſome improvements, with the reform of abuſes and pecuniary privileges:—the moſt able, and moſt intriguing, was the Conſtitutional party, or that which was deſirous of giving France a new monarchical conſtitution, but modified after the manner of the Engliſh, or even the American, by a houſe of repreſentatives. The third party was the moſt dangerous of all, by its daring ſpirit, by its power, and by the number of proſelytes it daily acquired in all quarters of the kingdom: it compriſed the Democrats of every deſcription, from the Jacobin clubs, calling themſelves *Friends of the Conſtitution*, to the anarchs and robbers.

" The Democratic party, which at firſt was only auxiliary to the Conſtitutional one, in the end annihilated it, and became itſelf ſubdivided into ſeveral other parties, whoſe fatal ſtruggles produced the ſubſequent revolutions, and may ſtill produce many more. But in principle, the Conſtitutionaliſts and the Democrats formed two diſtinct, though confederate, factions; both were deſirous of a revolution, and employed all the uſual means of accompliſhing it, except troops, which could be of no uſe to them, for neither of them had a leader to put at the head of the army. But as it was equally of importance to both that the king ſhould be deprived of the power of making uſe of it againſt them, they laboured in concert to diſorganiſe it; and the complete ſucceſs of that manœuvre was but too fully proved by the fatal iſſue of the departure of the royal family for Montmedi. The revolution then took a more 469
daring and rapid ſtride, which was concluded by the pretended conſtitution act of 1791. The incoherence of its principles, and the defects of its inſtitutions, preſent a faithful picture of the diſunion of its authors, and of the oppoſite intereſts by which they were ſwayed. It was, properly ſpeaking, a compact between the faction of the Conſtitutionaliſts and that of the Democrats, in which they mutually made conceſſions and ſacrifices.

Conſtitution of 1791 completes the firſt revolution.

" Be that as it may, this abſurd conſtitution, the everlaſting ſource of remorſe or ſorrow to all who bore part in it, might have been got over without a ſhock, and led back to the old principles of monarchical government, if the Aſſembly who framed it had not ſeparated before they witneſſed the execution of it; if, in impoſing on the king the obligation to maintain it, they had not deprived him of the power and the means; and above all, if the certain conſequence of the new mode of proceeding at the elections had not been to ſecure, in the ſecond Aſſembly, a conſiderable majority of the Democratic againſt the Conſtitutional party.

" The ſecond Aſſembly was alſo divided by three factions, the weakeſt of which was the one that wiſhed to maintain the conſtitution. The other two were for a new revolution and a republic; but they differed in this, that the former, compoſed of the Briſſotins and Girondiſts, was for effecting it gradually, by beginning with diveſting the king of popularity, and allowing the public

French Revolution.

public mind time to wean itfelf from its natural attachment to monarchy; and the latter, which was the leaft numerous, was eager to have the republic eftablifhed as foon as poffible. Thefe two factions, having the fame object in view, though taking different roads, were neceffarily auxiliaries to each other; and the pamphlets, excitations to commotion, and revolutionary meafures of both, equally tended to overthrow the conftitution of 1791.

"Thofe different factions, almoft entirely compofed of advocates, folicitors, apoftate priefts, doctors, and a few literary men, having no military chief capable of taking the command of the army, dreaded the troops, who had fworn allegiance to the conftitution, and obedience to the king, and who moreover might be influenced by their officers, among whom there ftill remained fome royalifts. The fureft way to get rid of all uneafinefs on this fubject, was to employ the army in defending the frontiers. For this purpofe a foreign war was neceffary, to which it was known that the king and his council were equally averfe. No more was wanting to determine the attack which was directed, almoft at the fame time, againft all the minifters, in order to compel them to retire, and to put the king under the neceffity of appointing others more difpofed to fecond the views of the parties. Unhappily this attempt was attended with all the fuccefs they had promifed themfelves; and one of the firft acts of the new miniftry was to declare war againft the Emperor. At the fame time, the emigration that had been provoked, and which was almoft everywhere applauded, even by the loweft clafs of people, robbed France of the flower of the royal party, and left the king, deprived of his beft defenders, expofed to the fufpicions and infults that fprang from innumerable calumnies, for which the difafters at the beginning of the war furnifhed but too many opportunities.

470 The fecond revolution.

"In this manner was prepared and accelerated the new revolution, which was accomplifhed on the 10th of Auguft 1792, by the depofition and imprifonment of the king, and by the moft flagrant violation of the conftitution of 1791. The latter, however, was not entirely abandoned on that day; for the project of the Girondifts, who had laid the plot of that horrible confpiracy, was then only to declare the king's depofition, in order to place the prince royal upon the throne, under the guidance of a regency compofed of their own creatures; but they were hurried away much farther than they meant to go, by the violence with which the moft furious of the Jacobins, who took the lead in the infurrection, conducted all their enterprifes. The prince royal, inftead of being crowned, was fhut up in the Temple; and if France at that moment was not declared a republic, it was lefs owing to any remaining refpect for the conftitution, than to the fear the legiflative body was in of raifing the army againft it, and alfo the majority of the nation, who would naturally be angry to fee a conftitution which feemed to be rendered fecure and ftable by fo many oaths, thus precipitately overthrown, without their having been confulted.

"It was on thefe confiderations that the opinion was adopted, that a National Convention fhould be convoked, to determine the fate of royalty. Prompt in feizing all the means that might enfure the fuccefs of this fecond revolution, the Affembly, under pretence of giving every poffible latitude to the freedom of elections, decreed, that all its members fhould be eligible for the National Convention.

"From that moment the Girondifts daily loft ground, and the moft flaming members of the Democratic party, fupported by the club of Jacobins, by the new Commune of Paris, and by the Tribunes, made themfelves mafters of every debate. It was of the utmoft importance to them to rule the enfuing elections; and this was fecured to them by the horrible conflernation which the maffacres of the 2d of September ftruck throughout the kingdom. The terror of being affaffinated, or at leaft cruelly treated, drove from all the Primary Affemblies, not only the royalifts and conftitutionalifts, but moderate men of all parties. Of courfe, thofe affemblies became entirely compofed of the weakeft men and the greateft villains exifting in France; and from among the moft frantic of them were chofen thofe members of the Convention who were not taken from the legiflative body. Accordingly, this third Affembly, in the firft quarter of an hour of their firft fitting, were heard fhouting their votes for the abolition of royalty, and proclaiming the republic, upon the motion of a member who had formerly been a player.

"Such an opening but too plainly fhewed what was to be expected from that horde of plunderers which compofed the majority of the National Convention, and of whom Robefpierre, Danton, Marat, and the other ringleaders, formed their party. That of the Briffotins and Girondifts ftill exifted, and was the only one really republican. Thefe femi-wretches, glutted with the horrors already committed, feemed defirous of arrefting the torrent of them, and laboured to introduce into the Affembly the calm and moderation that were neceffary to give the new republic a wife and folid organization. But the fuperiority of their knowledge, talents, and eloquence, which their opponents could not difpute, had no power over tigers thirfting for blood, who neither attended to nor fuffered motions but of the blackeft tendency. No doubt they had occafion for atrocities upon atrocities to prepare the terror-ftruck nation to allow them to commit, in its name, the moft execrable of all, the murder of the unfortunate Louis XVI.: and that martyrdom was neceffary to bring about a third revolution, already brewing in the brain of Robefpierre. Fear had greatly contributed to the two former: but this was effected by terror alone, without popular tumults, or the intervention of the armies; which, now drawn by their conquefts beyond the frontiers, never heard any thing of the revolutions at home, till they were accomplifhed, and always obeyed the prevailing faction, by whom they were paid. 471 The third revolution.

"By the decree of ferocity difcovered by the members of the Convention in paffing fentence upon the king, and in the debates relative to the conftitution of 1793, Robefpierre was enabled to mark which of the deputies were likely to fecond his views, and which of them it was his part to facrifice.

"The people could not but with tranfport receive a conftitution which feemed to realife the chimera of its fovereignty, but which would only have given a kind of conftruction to anarchy, if the execution of this new code had not been fufpended under the pretext, belonging in common to all acts of defpotifm and tyranny, of *the fupreme law of the fafety of the ftate.* This fufpen-

French Revolution.

sion was effected, by establishing the Provisionary Government, which, under the title of Revolutionary Government, concentrated all the powers in the National Convention until there should be an end to the war and all intestine troubles.

" Although the faction, at the head of which Robespierre was, had a decided majority in the assembly, and might consequently have considered themselves as really and exclusively exercising the sovereign power, he was a demagogue of too despotic a nature to stomach even the appearance of sharing the empire with so many co-sovereigns. He greatly reduced their number, by causing all the powers invested in the National Assembly by the decrees that had established the revolutionary government, to be transferred to a committee, to which he got himself appointed, and where he was sure of the sole rule, by obtaining for colleagues men less daring than himself, though equally wicked; such as Couthon, St Just, Barrere, and others like them. This committee, who had the assurance to style themselves the *Committee of Public Safety*, very soon seized upon both the legislative and executive powers, and exercised them with the most sanguinary tyranny ever yet heard of. The ministers were merely their clerks; and the subjugated Assembly, without murmur or objection, passed all the revolutionary laws which were proposed, or rather dictated, by them. One of their most horrible and decisive conceptions was that of those Revolutionary tribunals which covered France with scaffolds, where thousands of victims of every rank, age, and sex, were daily sacrificed; so that no class of men could be free from that stupifying and general terror which Robespierre found it necessary to spread, in order to establish and make his power known. He soon himself dragged some members of his own party, such as Danton, Camille des Moulins, and others, whose energy and popularity had offended him, before one of those tribunals, where he had them condemned to death. By the same means he got rid of the chief leaders among the Brissotines and Girondists; while he caused all the moderate republican party, who were still members of the Assembly, except those who had time and address to escape, to be sent to prison, in order to be sentenced and executed on the first occasion.

472 The fourth revolution produces

" In this manner ended the third revolution, in which the people, frozen with terror, did not dare to take a part. Instead of an army of soldiers, Robespierre employed an army of executioners and assassins, set up as revolutionary judges; and the guillotine, striking or menacing all heads indiscriminately, made France, from one end to the other, submit to him, by the means of terror or of death. Thus was this nation, formerly so proud, even to idolatry, of its kings, seen to expiate, by rivers of blood, the crime of having suffered his to be spilt who was the most virtuous of all their monarchs.

" In the room of that famous Bastile, whose celebrated capture and demolition had set only seven prisoners at liberty, two of whom had been long in a state of lunacy, the colleges, the seminaries, and all the religious houses of the kingdom, were converted into so many state prisons, into which were incessantly crowded, from time to time, the victims devoted to feed the ever-working guillotines, which were never suffered to stand still for a day, because they were at once the chief resource of supplies for the government, and the instrument of its ferocity. ' The guillotine coins money for the republic,' was said in the tribune by one of Robespierre's vilest agents *. In fact, according to the jurisprudence of the Revolutionary Tribunals, the rich of every class, being declared suspected persons, received sentence of death, for no other reason than that of giving the confiscation of their property a show of judicial form.

* *Barrere.*

" Still blood flowed too slowly to satisfy Robespierre; his aim was but partly attained by the proscription of the nobles, the priests, and the wealthy. He fancied, not only an aristocracy of talents and knowledge, but of the virtues, none of which would his trusty orators and journalists admit, save that horrid *patriotism* which was estimated according to the enormity of the crimes committed in favour of the revolution. His plan was to reduce the French people to a mere plantation of slaves, too ignorant, too stupid, or too pusillanimous, to conceive the idea of breaking the chains with which he would have loaded them in the name of liberty; and he might have succeeded in it, had not his ambition, as impatient as it was jealous, too soon unveiled the intention of resorting to the guillotine to strike off the shackles with which an assembly of representatives of the nation fettered, or might fetter, his power. He was about to give this decisive blow, which he had concerted with the Commune of Paris, the Revolutionary Tribunal, the Club of Jacobins, and the principal officers of the National Guard, when the members of the Convention, who were marked out to be the first sacrificed, anticipated him at a moment when he least expected it, by attacking himself in the Assembly, with energy sufficient to rouse all the sections of the capital against him and against the Jacobins. The parties came to blows, and victory remained uncertain for several hours; but at length declared against Robespierre. In the space of a day, that execrable monster was dragged from the highest pitch of power ever attained by any tyrant, to the very scaffold that was still reeking with the blood of his last victims. His principal accomplices in the Committee of Public Safety, in the Commune, in the National Guard, in the Revolutionary Tribunal, and many of his agents in the provinces, met the same fate. The Revolutionary Tribunals were suppressed, and the prisons thrown open to all whom they had cast into them.

473 The constitution of 1795.

" This fourth revolution, in which the faction then esteemed the moderate party overthrew the terrorists, and seized the supreme power, was no less complete than those which had preceded it, and produced the constitution of 1795. All France received as a great blessing a constitution that delivered them from the revolutionary government and its infernal policy. Besides, it had, in spite of great defects, the merit of coming nearer than the two preceding ones, to the principles of order, of justice, and real liberty; the violation of which had, for five years before, been the source of so many disasters and so many crimes. The royalists, considering it as a step towards monarchy, were unfortunately so imprudent as to triumph in it; and their joy, as premature as indiscreet, alarmed the Assembly to such a degree, that they passed the famous law, ordaining the Primary Assemblies to return two-thirds of the members of the Convention to the legislative body, which

was

French Revolution.

was to succeed that assembly. It was thus that the spirit of the Convention continued, for the first year, to be displayed in the two councils.

"In the year following, the bias of the public mind, perhaps too hastily turned towards royalty, shewed itself in the elections of the members for the new third, so clearly as to alarm the regicides who composed the Directory, and the Conventionalists, who still made a third of the legislative body; nor did they lose a moment in devising means for their defence. That which appeared the surest to them was, to publish notices of plots among the royalists, and annex one or more denunciations, in terms so vague as to leave room for implicating, when necessary, all their adversaries; while by the help of this imposture they procured some secret information, artfully fabricated, and ever easily obtained through threats or rewards by those who have at command the guillotine and the public treasure.

"This masked battery was ready to be opened before the members of the new third took their seats. These at first confined themselves to the securing of a constant majority in the two councils in favour of the moderate opinions; but in a little time every sitting was marked by the repeal of some revolutionary law, or by some decree tending to restrain the executive authority within the limits fixed by the constitution.

473 The fifth revolution.

"The Directory, alarmed at the abridgment of their power, and dreading still more serious attacks upon it, came to a resolution of no longer postponing the blow they had been meditating against the legislative assembly: and they accomplished, in the manner related in n° 309. a fifth revolution, as complete as any of those by which it was preceded. It differed indeed from them essentially in the facility and promptness with which it was effected, although the party which prevailed, that is to say, the majority of the Directory, and the minority of the Legislative Body, had to combat not only against the constitution, but against the opinion, and even against the indignation, of the public. That moral force, on which the majority of the two councils had unluckily placed all their reliance, vanished in an instant before the physical force of a detachment of troops consisting of six or seven hundred men; so true is it that the power of the public opinion, ridiculously exaggerated in these days, is and can be no more, under a firm and well ordered government, than a mere fancy. Men accustom themselves too easily to take for public opinion the private opinions made public by certain writers, whose caution or audaciousness depends always upon the energy or feebleness of the supreme authority. It is the same thing with popular commotions: they are easily excited under a weak government, which does not possess the wisdom to prevent or the spirit to suppress them; but a vigorous, just, and strict government has nothing to fear from them. The Directory, compelled to withdraw the larger body of troops, which they had thought necessary to ensure the revolution they were meditating, discovered, no doubt, great ability in securing the two councils, by appearing to dread them: but it was chiefly to the energy of their measures, and to the concentration and promptness with which they were executed, that they owed their success. Two days before, the legislative body might, without obstruction, have impeached, arrested, and even outlawed, the majority of the Directory, who were execrated by the public under the title of Triumvirate; and, if requisite, they would have been supported by more than 30,000 armed citizens, who, with Pichegru and Villot at their head, would soon have dispersed, and perhaps brought over, the feeble detachments of troops of the line which the Directory had at their command. The legislative body, relying too much upon its popularity, did not sufficiently consider, that the people, whose impetuosity is commonly decisive when allowed to take advantage in attack, are always feeble on the defensive, and totally unable to withstand every assault made previous to an insurrection, for it is always easy to prevent their assembling. It was on this principle that the Directory founded their operations, and the 5th of September too well proves how justly. That day reduced the legislative body, by the most degrading subjugation, to a mere disgusting caricature of national representation; it invested the Directory with the most arbitrary and tyrannic power, and restored the system of Robespierre, under a form less bloody, but not less pernicious; for the Revolutionary Tribunals which that monster had established, were scarcely more expeditious than the military ones of the Directory. The power of arbitrary and unlimited transportation is, in time, as destructive as the guillotine, without possessing, like that, the advantage of exciting a salutary horror, which, by recovering the people from the state of stupor and apathy, the constant effects of terror, gives them both recollection and force to break their chains. Though, in violating the most essential regulations of the constitution, the Directory obtained a temporary confirmation of their power, their example pointed out to Bonaparte and Sieyes the path which they pursued with infinite address, and in which they accomplished a sixth revolution." 474 The sixth revolution, and consular government.

How long the consular government will continue, it is impossible to conjecture; but Bonaparte has laboured successfully to reconcile to it a great part of the nation. Soon after his succession, he relaxed the severity of the existing laws against the emigrants; and he has, from time to time, struck off such numbers from the black roll of Robespierre and the Directory, that many persons, known to be royalists, as well as members of the constituent assembly, have returned to France, and enjoyed offices of trust under his government. To some he has even restored such parts of their estates as were not, by a deed of the nation, in the possession of other individuals; and he gives no countenance at his court to the Jacobinical appellation of *Citizen*, or the rest of the slang of liberty and equality.

The Cardinals had, at Venice, proceeded to the election of a Pope, while Rome was in the possession of the troops of the Directory; but the Emperor, having restored that city, together with the wreck of the ecclesiastical state, to the new Pontiff, the Chief Consul, after the battle of Marengo, not only acquiesced in the measure, but, as soon as he was firmly seated on his throne, made overtures to his Holiness for the readmission of France into the bosom of the church. This was the most judicious step that he could have taken, and the best calculated to support his authority. Having no religion himself, he was induced to establish the Catholic in preference to the Reformed, only because he found it most agreeable to the majority of the French people; but he granted to the Protestants the most li- 475 The restoration of Christianity in France.

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French Revolution. beral toleration, and ſeems, by his concordate with the Pope, to have retained to himſelf an authority over the church little ſhort of that which was aſſumed by Henry VIII. of England, when he broke off all correſpondence with the court of Rome.

Theſe meaſures were ſo popular, that when he reſtored peace to the republic, he was ſuddenly choſen Conſul for life; and it was even propoſed by ſome of his creatures to convert the republic into an *empire*, and create him the *firſt Emperor of the Gauls*. This propoſal, however, was ſupported by no party. The royaliſts could not give their vote for elevating a foreigner to a higher rank than was ever held by that auguſt family, for the ſupport of which they had hazarded their lives and fortunes. The genuine democrat ſubmitted with reluctance to the power of a Conſul, and abhorred the very ſound of the words *Emperor* and *empire*. Even the moderate conſtitutionaliſt, who thinks it his duty to ſupport every government which happens to be eſtabliſhed, was aſhamed to relinquiſh ſo openly the principles which had induced him to rebel againſt Louis
477 Bonaparte Conſul for life. XVI. Bonaparte was therefore not made an Emperor, but a *Conſul for life*, with more than Imperial power; and was authoriſed to nominate his ſucceſſor, in the event of his dying without male iſſue.

If this laſt revolution operate not as a warning to all the nations of Europe, ſhewing them the extreme danger of ſudden and violent innovations in the government of a great ſtate; if it convince them not that the ſovereignty of the people is, in ſuch a ſtate, the parent of individual deſpotiſm; and that the principles of democracy, however plauſible they may appear in a political eſſay, cannot be carried into practice—we muſt conclude that theſe nations are incapable of learning wiſdom from experience. In the 17th century the conſtitution of Great Britain was overturned, and a virtuous monarch murdered, to make way for a republic, which ſoon gave place to the military deſpotiſm of a private Engliſh gentleman. In the ſucceeding century a crew of lawyers and philoſophiſts, who, under the denomination of the ſtates general, had been called together to deviſe ſome remedy for the diſorder into which the finances of France had fallen, ſnatched the ſceptre from the hands of their mild ſovereign, who was ſoon afterwards brought to the block. In France, as in England, the monarchy was ſucceeded by a democratical government, exceeding in tyranny and cruelty all the deſpotiſms of ſingle men, whether called Kings or
478 Conſequences of violent innovations. Emperors, that the world has yet ſeen. There, too, the democracy gave place to the military deſpotiſm of a private gentleman; but that gentleman is not a native, but a foreign adventurer, of a family never heard of beyond the limits of the little iſle of Corſica till after the commencement of the revolution, which involved all Europe in its vortex. If the conſular government continue, the reign of equality is indeed at an end; but the ſurrounding nations have more to dread from conſular ambition, than they had to dread from the ambition of Louis XIV. when he was at the ſummit of his glory and his arrogance. Many circumſtances conſpired to reſtrain his Majeſty's ambition within certain limits; but the ambition of him who has no ſon to ſucceed him, and who is placed in ſuch a ſituation, that events may fall out which will preſent to him no perſonal ſafety but in foreign war, is obviouſly under no reſtraint. All this might have been prevented had the coaleſced powers, at the beginning of the conteſt, acted conſcientiouſly on the principles ſo ably enforced by that illuſtrious ſtateſman Mr Burke; but the King of Pruſſia's jealouſy of the Houſe of Auſtria made him abandon the cauſe, and, for the ſake of humbling his rival, ſacrifice Europe to the ambition of France.

Rhabdology || Rice.

RHABDOLOGY, or RABDOLOGY, in arithmetic, a name given by Napier to a method of performing ſome of the more difficult operations of numbers by means of certain ſquare little rods. Upon theſe are inſcribed the ſimple numbers; then by ſhifting them according to certain rules, thoſe operations are performed by ſimply adding or ſubtracting the numbers as they ſtand upon the rods. See Napier's *Rabdologia*, printed in 1617. See alſo the article *NAPIER's Bones*.

RHOMB SOLID, conſiſts of two equal and right cones joined together at their baſes.

RICE (ſee that article, and ORYZA, *Encycl.*) is ſtrongly recommended, in a late publication, as the beſt corrective of *ſprit* flour, of which there is a great quantity in Scotland every year, and of courſe a great deal of unpleaſant and unwholeſome bread. The gentleman, who writes the ſhort paper alluded to, directs ten pounds of flour and one pound of ground rice, with the uſual quantity of yeſt, to be placed, for about two hours, before a fire, and then formed into bread in the common way. This addition of rice, beſides correcting the bad qualities of the damaged flour, adds, he ſays, much to its nutriment: and he is undoubtedly right; for the flour of rice, though very nutritious, is ſo dry, that it is difficult to make bread of it by itſelf. See *BREAD of Rice* in this *Suppl.*

As rice is a favourite ſubſtitute for bread in years of ſcarcity, it may not be diſagreeable to our readers to know the method of cultivating the plant in thoſe countries where it is the principal food of the inhabitants. We have the following full and perſpicuous account of the Chineſe practice by Sir George Staunton.

"Much of the low grounds in the middle and ſouthern provinces of the empire are appropriated to the culture of that grain. It conſtitutes, in fact, the principal part of the food of all thoſe inhabitants, who are not ſo indigent as to be forced to ſubſiſt on other and cheaper kinds of grain. A great proportion of the ſurface of the country is well adapted for the production of rice, which, from the time the ſeed is committed to the ſoil till the plant approaches to maturity, requires to be immerſed in a ſheet of water. Many and great rivers run through the ſeveral provinces of China, the low grounds bordering on thoſe rivers are annually inundated, by which means is brought upon their ſurface a rich mud or mucilage that fertilizes the ſoil, in the ſame manner as Egypt receives its fecundative quality from the overflowing of the Nile. The periodical rains which fall near the ſources of the Yellow and the Kiang rivers, not very far diſtant from thoſe of the Ganges and the Burampooter, among the mountains bounding India to the north, and China to the weſt, often ſwell thoſe rivers to a prodigious height, though not a drop of rain ſhould have fallen on the plains through which they afterwards flow.

"After the mud has lain ſome days upon the plains in China, preparations are made for planting them with rice. For this purpoſe, a ſmall ſpot of ground is incloſed

Rice.

closed by a bank of clay; the earth is ploughed up; and an upright harrow, with a row of wooden pins in the lower end, is drawn lightly over it by a buffalo. The grain, which had previously been steeped in dung diluted with animal water, is then sown very thickly on it. A thin sheet of water is immediately brought over it, either by channels leading to the spot from a source above it, or when below it by means of a chain pump, of which the use is as familiar as that of a hoe to every Chinese husbandman. In a few days the shoots appear above the water. In that interval, the remainder of the ground intended for cultivation, if stiff, is ploughed, the lumps broken by hoes, and the surface levelled by the harrow. As soon as the shoots have attained the height of six or seven inches, they are plucked up by the roots, the tops of the blades cut off, and each root is planted separately, sometimes in small furrows turned with the plough, and sometimes in holes made in rows by a drilling stick for that purpose. The roots are about half a foot asunder. Water is brought over them a second time. For the convenience of irrigation, and to regulate its proportion, the rice fields are subdivided by narrow ridges of clay, into small inclosures. Through a channel, in each ridge, the water is conveyed at will to every subdivision of the field. As the rice approaches to maturity, the water, by evaporation and absorption, disappears entirely; and the crop, when ripe, covers dry ground. The first crop or harvest, in the southern provinces particularly, happens towards the end of May or beginning of June. The instrument for reaping is a small sickle, dentated like a saw, and crooked. Neither carts nor cattle are used to carry the sheaves off from the spot where they were reaped; but they are placed regularly in frames, two of which, suspended at the extremities of a bamboo pole, are carried across the shoulders of a man, to the place intended for disengaging the grain from the stems which had supported it. This operation is performed, not only by a flail, as is customary in Europe, or by cattle treading the corn in the manner of other Orientalists, but sometimes also by striking it against a plank set upon its edge, or beating it against the side of a large tub scolloped for that purpose; the back and sides being much higher than the front, to prevent the grain from being dispersed. After being winnowed, it is carried to the granary.

"To remove the skin or husk of rice, a large strong earthen vessel, or hollow stone, in form somewhat like that which is used elsewhere for filtering water, is fixed firmly in the ground; and the grain, placed in it, is struck with a conical stone fixed to the extremity of a lever, and cleared, sometimes indeed imperfectly, from the husk. The stone is worked frequently by a person treading upon the end of the lever. The same object is attained also by passing the grain between two flat stones of a circular form, the upper of which turns round upon the other, but at such a distance from it as not to break the intermediate grain. The operation is performed on a large scale in mills turned by water; the axis of the wheel carrying several arms, which, by striking upon the ends of levers, raise them in the same manner as is done by trading on them.. Sometimes twenty of these levers are worked at once. The straw from which the grain has been disengaged is cut chiefly into chaff, to serve as provender for the very few cattle employed in Chinese husbandry.

Rideau, Ridley.

"The labour of the first crop being finished, the ground is immediately prepared for the reception of fresh seeds. The first operation undertaken is that of pulling up the stubble, collecting it into small heaps, which are burnt, and the ashes scattered upon the field. The former processes are afterwards renewed. The second crop is generally ripe late in October or early in November. The grain is treated as before; but the stubble is no longer burnt. It is turned under with the plough, and left to putrefy in the earth. This, with the slime brought upon the ground by inundation, are the only manures usually employed in the culture of rice."

RIDEAU, in fortification, a small elevation of earth, extending itself lengthwise on a plain; serving to cover a camp, or give an advantage to a post.

RIDEAU is sometimes also used for a trench, the earth of which is thrown up on its side, to serve as a parapet for covering the men.

RIDLEY (Dr Gloster), was of the same family with D. Nicolas Ridley, Bishop of London, and martyr to the Reformation. (See RIDLEY, *Encycl.*) He was born at sea, in 1702, on board the Gloucester East Indiaman; to which circumstance he was indebted for his Christian name. He received his education at Winchester school, and thence was elected to a fellowship at New college, Oxford, where he proceeded B. C. L. April 29. 1729. In those two seminaries he cultivated an early acquaintance with the muses, and laid the foundation of those elegant and solid acquirements for which he was afterwards so eminently distinguished as a poet, an historian, and a divine. During a vacancy in 1728, he joined with four friends. viz. Mr Thomas Fletcher (afterwards Bishop of Kildare), Mr (afterwards Dr) Eyre, Mr Murrison, and Mr Jennens, in writing a tragedy called "The Fruitless Redress," each undertaking an act on a plan previously concerted.. When they delivered in their several proportions at their meeting in the winter, few readers would have known that the whole was not the production of a single hand. This tragedy, which was offered to Mr Wilks, but never acted, is still in MS. with another called "Jugurtha." Dr Ridley in his youth was much addicted to theatrical performances. Midhurst, in Sussex, was the place where they were exhibited; and the company of gentlemen actors to which he belonged consisted chiefly of his coadjutors in the tragedy already mentioned. He is said to have performed the characters of Marc Antony, Jaffier, Horatio, and Moneses, with distinguished applause; a circumstance that will be readily believed by those who are no strangers to his judicious and graceful manner of speaking in the pulpit.

For great part of his life he had no other preferment than the small college living of Westow in Norfolk, and the donative of Poplar in Middlesex, where he resided. To these his college added, some years after, the donative of Romford in Essex. "Between these two places the curricle of his life had (as he expressed it) rolled for some time almost perpetually upon postchaise wheels, and left him not time for even the proper studies of economy, or the necessary ones of his profession." Yet in this obscure situation he remained in possession of, and

Rienzi.

and content with domestic happiness; and was honoured with the intimate friendship of some who were not less distinguished for learning than for worth.

In 1740 and 1741 he preached "Eight Sermons at Lady Moyer's Lecture," which were published in 1742, 8vo. In 1756 he declined an offer of going to Ireland as first chaplain to the Duke of Bedford; in return for which he was to have had the choice of promotion, either at Christ-church, Canterbury, Westminster, or Windsor. His modesty inducing him to leave the choice of these to his patron, the consequence was, that he obtained none of them. In 1763, he published the "Life of Bishop Ridley," in 4to, by subscription, and cleared by it as much as brought him 800l. in the public funds. In the latter part of his life he had the misfortune to lose both his sons, each of them a youth of abilities. The elder, James, was author of "The Tales of the Genii," and some other literary performances. Thomas, the younger, was sent by the East India Company as a writer to Madras, where he was no sooner settled than he died of the small-pox. In 1765, Dr Ridley published his "Review of Philips's Life of Cardinal Pole; and in 1768, in reward for his labours in this controversy, and in another which "The Confessional" produced, he was presented by Archbishop Secker to a golden prebend in the cathedral church of Salisbury (an option), the only reward he received from the great during a long, useful, and laborious life, devoted to the duties of his function. At length, worn out with infirmities, he departed this life in 1774, leaving a widow and four daughters. His epitaph, which was written by Bishop Lowth with his usual elegance, informs us, that for his merits the university of Oxford conferred upon him the degree of D. D. by diploma, which is the highest literary honour which that learned body has to bestow.

RIENZI (Nicolas Gabrini de), one of the most extraordinary men of the 14th century, was born at Rome, we know not in what year. His father, Lawrence Gabrini, was a mean vintner, or, as others say, a miller, and his mother a laundress. These persons, however, found the means of giving their son a liberal education; and to a good natural understanding he joined an uncommon assiduity, and made great proficiency in ancient literature. Every thing which he read he compared with similar passages that occurred within his own observation; whence he made reflections, by which he regulated his conduct. To this he added a great knowledge in the laws and customs of nations. He had a vast memory: he retained much of Cicero, Valerius Maximus, Livy, the two Senecas, and Cæsar's Commentaries especially, which he read continually, and often quoted by application to the events of his own times. This fund of learning proved the basis and foundation of his rise. The desire he had to distinguish himself in the knowledge of monumental history, drew him to another sort of science, in which few men at that time exerted themselves. He passed whole days among the inscriptions which are to be found at Rome, and acquired soon the reputation of a great antiquary. Having hence formed within himself the most exalted notions of the justice, liberty, and ancient grandeur of the old Romans, words he was perpetually repeating to the people, he at length persuaded not only himself, but the giddy mob his followers, that he should one day become the restorer of the Roman republic. His advantageous stature, his countenance, and that air of importance which he well knew how to assume, deeply imprinted all that he said in the minds of his audience.

Rienzi.

Nor was it only by the populace that he was admired; he also found means to insinuate himself into the favour of those who partook of the administration. Rienzi's talents procured him to be nominated one of the deputies sent by the Romans to Pope Clement VI. who resided at Avignon. The intention of this deputation was to make his Holiness sensible, how prejudicial his absence was, as well to himself as to the interest of Rome. At his first audience, our hero charmed the court of Avignon by his eloquence and the sprightliness of his conversation. Encouraged by success, he one day took the liberty to tell the Pope, that the grandees of Rome were avowed robbers, public thieves, infamous adulterers, and illustrious profligates; who, by their example, authorised the most horrid crimes. To them he attributed the desolation of Rome; of which he drew so lively a picture, that the Holy Father was moved, and exceedingly incensed against the Roman nobility. Cardinal Colonna, in other respects a lover of real merit, could not help considering these reproaches as reflecting upon some of his family; and therefore found means of disgracing Rienzi, so that he fell into extreme misery, vexation, and sickness, which, joined with indigence, brought him to an hospital. Nevertheless, the same hand that threw him down, raised him up again. The cardinal, who was all compassion, caused him to appear before the Pope, in assurance of his being a good man, and a great partizan for justice and equity. The Pope approved of him more than ever; and to give him proofs of his esteem and confidence, made him apostolic notary, and sent him back loaded with favours.

Being returned to Rome, he began to execute the functions of his office; and by affability, candour, assiduity, and impartiality, in the administration of justice, he arrived at a superior degree of popularity; which he still improved by continued invectives against the vices of the great, whom he took care to render as odious as possible; till at last, for some ill timed freedoms of speech, he was not only severely reprimanded, but displaced. From this time it was his constant endeavour to inspire the people with a fondness for their ancient liberties; to which purpose he caused to be hung up in the most public places emblematic pictures, expressive of the former splendour and present decline of Rome. To these he added frequent harangues and predictions upon the same subject. In this manner he proceeded till one party looked on him only as a madman, while others caressed him as their protector. At length he ventured to open himself to such as he believed mal-contents. At first he took them separately; afterwards, when he thought he had firmly attached a sufficient number to his interest, he assembled them together, and represented to them the deplorable state of the city, over-run with debaucheries, and the incapacities of their governors to correct or amend them. As a necessary foundation for the enterprise, he gave them an insight into the immense revenues of the apostolic chamber: He demonstrated, that the Pope could, only at the rate of fourpence, raise a hundred thousand florins

Rienzi. rins by firing, as much by falt, and as much more by the cuftoms and other duties. As for the reft, faid he, I would not have you imagine that it is without the Pope's confent I lay hands on the revenues. Alas! how many others in this city plunder the effects of the church contrary to his will!

By this artful lie, he fo animated his auditors, that they declared they would make no fcruple of fecuring thefe treafures for whatever end might be moft convenient; and that they were devoted to the will of him their chief. Having obtained fo much, to fecure his adherents from a revolt, he tendered them a paper, fuperfcribed, "an *oath* to procure the good eftablifhment;" and made them fubfcribe and fwear to it before he difmiffed them. By what means he prevailed on the Pope's vicar to give a tacit fanction to his project, is not certainly known; that he did procure that fanction, and that it was looked on as a mafterpiece of policy, is generally admitted. "The 20th of May, being Whitfunday, he fixed upon to fanctify in fome fort his enterprife; and pretended, that all he acted was by particular infpiration of the Holy Ghoft. About nine, he came out of the church bare-headed, accompanied by the Pope's vicar, furrounded by an hundren armed men. A vaft crowd followed him with fhouts and acclamations." The gentlemen confpirators carried three ftandards before him, on which were wrought devices, infinuating, that his defign was to re-eftablifh liberty, juftice, and peace. In this manner he proceeded directly to the Capitol, where he mounted the roftrum; and, with more boldnefs and energy than ever, expatiated on the miferies to which the Romans were reduced: at the fame time telling them, without hefitation, "that the happy hour of their deliverence was at length come, and that he was to be their deliverer, regardlefs of the dangers he was expofed to for the fervice of the Holy Father and the people's fafety." After which, he ordered the laws of what he called the good eftablifhment to be read: "affured that the Romans would refolve to obferve thefe laws, he engaged in a fhort time to re-eftablifh them in their ancient grandeur."

The laws of the good eftablifhment promifed plenty and fecurity, which were greatly wanted; and the humiliation of the nobility, who were deemed common oppreffors. Such laws could not fail of being agreeable to a people who found in them thefe double advantages; wherefore, "enraptured with the pleafing ideas of a liberty to which they were at prefent ftrangers, and the hope of gain, they came moft zealoufly into the fanaticifm of Rienzi. They refumed the pretended authority of the Romans; they declared him fovereign of Rome; and granted him the power of life and death, of rewards and punifhments, of enacting and repealing the laws, of treating with foreign powers; in a word, they gave him the full and fupreme authority over all the extenfive territories of the Romans.

Rienzi, arrived at the fummit of his wifhes, kept at a great diftance his artifice: he pretended to be very unwilling to accept of their offers, but upon two conditions; the firft, that they fhould nominate the Pope's vicar (the Bifhop of Orvieto) his copartner; the fecond, that the Pope's confent fhould be granted him, which (he told them) he flattered himfelf he fhould obtain. "On the other hand, he hazarded nothing in thus making his court to the Holy Father; and, on the other, he well knew, that the Bifhop of Orvieto would carry a title only, and no authority. The people granted his requeft, but paid all the honours to him: he poffeffed the authority without reftriction; the good Bifhop appeared a mere fhadow and veil to his enterprifes. Rienzi was feated in his triumphal chariot, like an idol, to triumph with the greater fplendour. He difmiffed the people replete with joy and hope. He feized upon the palace, where he continued after he had turned out the fenate; and, the fame day, he began to dictate his laws in the Capitol." This election, though not very pleafing to the Pope, was ratified by him; neverthelefs, Rienzi meditated the obtaining of a title, exclufive of the papal prerogative. Well verfed in the Roman hiftory, he was no ftranger to the extent of the tribunitial authority; and as he owed his elevation to the people, he chofe to have the title of their magiftrate. He afked it, and it was conferred on him and his copartner, with the addition of deliverers of their country. Our adventurer's behaviour in his elevation was at firft fuch as commanded efteem and refpect, not only from the Romans, but from all the neighbouring ftates. But it is difficult for a perfon of mean birth, elevated at once, by the caprice of fortune, to the moft exalted ftation, to move rightly in a fphere wherein he muft breathe an air he has been unaccuftomed to. Rienzi afcended by degrees the fummit of his fortune. Riches foftened, power dazzled, the pomp of his cavalcades animated, and formed in his mind ideas adequate to thofe of princes born to empire. Hence luxury invaded his table, and tyranny took poffeffion of his heart. The Pope conceived his defigns to be contrary to the interefts of the holy fee; and the nobles, whofe power it had been his conftant endeavours to deprefs, confpired againft him: they fucceeded; and Rienzi was forced to quit an authority he had poffeffed little more than fix months. It was to a precipitate flight that he was indebted, at this juncture, for his life; and to different difguifes for his fubfequent prefervation.

Having made an ineffectual effort at Rome, and "not knowing where to find a new refource to carry on his defigns he took a moft bold ftep, conformable to that rafhnefs which had fo often affifted him in his former exploits. He determined to go to Prague, to Charles king of the Romans, whom the year before he had fummoned to his tribunal," and who, he forefaw, would deliver him up to a Pope highly incenfed againft him. He was accordingly foon after fent to Avignon, and there thrown into a prifon, where he continued three years. The divifions and difturbances in Italy, occafioned by the number of petty tyrants that had eftablifhed themfelves in the ecclefiaftical territories, and even at Rome, occafioned his enlargement. Innocent VI. who fucceeded Clement in the papacy, fenfible that the Romans ftill entertained an affection for our hero, and believing that his chaftifement would teach him to act with more moderation than he had formerly done, as well as that "gratitude would oblige him, for the remainder of his life, to preferve an inviolable attachment to the holy fee (by whofe favour he fhould be re-eftablifhed)," thought him a proper inftrument to affift his defign of reducing thofe other tyrants; and therefore, not only gave him his liberty, but alfo appointed him governor and fenator of Rome. He met with many obftacles to the affumption of this newly-granted authority; all which, by cunning and refolution, he at length overcame. But giving way to his paffions, which were immoderately warm, and inclined him to cruelty, he excited fo general a refentment againft him that he was murdered October 8. 1354.

"Such was the end of Nicolas Rienzi, one of the moft renowned men of the age; who, after forming a confpiracy full of extravagance, and executing it in the fight of almoft the whole world, with fuch fuccefs that he became fovereign of Rome; after caufing plenty, juftice, and liberty, to flourifh among the Romans; after protecting potentates, and terrifying fovereign princes; after being arbiter of crowned heads; after re-eftablifhing the ancient majefty and power of the Roman republic, and filling all Europe with his fame during the feven months of his firft reign; after having compelled his mafters themfelves to confirm him in the authority he had ufurped againft their interefts—fell at length at the end of his fecond, which lafted not four months, a facrifice to the nobility whofe ruin he had vowed, and to thofe vaft projects which his death prevented him from putting into execution *."

* Biog. Dict. new edit.

If the reader perceive any thing fimilar at prefent to the rife of this wonderful man to fovereign authority, he may perhaps confole himfelf with the hope that the modern conful will in all probability fall like the modern tribune. Both rofe by difplays of the moft daring courage; the affociates of both were priefts, who in the actual exercife of government were cyphers; both promifed liberty and plenty to the people whom they ruled with abfolute fway; and both have trampled upon the order of nobility.

RING, in aftronomy and navigation, an inftrument ufed for taking the fun's altitude, &c. It is ufually of brafs, about nine inches diameter, fufpended by a little fwivel, at the diftance of 45°, from the point of which is a perforation, which is the centre of a quadrant of 90° divided in the inner concave furface. To ufe it, let it be held up by the fwivel, and turned round to the fun, till his rays, falling through the hole, make a fpot among the degrees, which marks the altitude required. This inftrument is preferred before the aftrolabe, becaufe the divifions are here larger than on that inftrument.

ROBERVALLIAN LINES, a name given to certain lines ufed for the transformation of figures; thus called from their inventor Roberval, an eminent French mathematician, who died in 1675, aged 76 years. Thefe lines bound fpaces that are infinitely extended in length, which are neverthelefs equal to other fpaces that are terminated on all fides.

The Abbot Gallois, in the Memoirs of the Royal Academy, anno 1693, obferves, that the method of transforming figures, explained at the latter end of Roberval's Treatife of Indivifibles, was the fame with that afterwards publifhed by James Gregory, in his *Geometria Univerfalis*, and alfo by Barrow in his *Lectiones Geometricæ;* and that, by a letter of Torricelli, it appears that Roberval was the inventor of this manner of transforming figures, by means of certain lines, which Torricelli therefore called *Robervallian lines*. He adds, that it is highly probable that J. Gregory firft learned the method in the journey he made to Padua in 1668, the method itfelf having been known in Italy from the year 1646, though the book was not publifhed till the year 1692.

This account has been, we think, completely refuted by David Gregory in his vindication of his uncle, publifhed in the Philofophical Tranfactions of 1694. The Abbot, however, rejoined in the Memoirs of the French Academy of 1703; and it is but fair to obferve, that Dr Hutton, fpeaking of the controverfy, expreffes himfelf as if he thought it undecided.

ROCKET (fee *Encycl.* vol. xvi. p. 316.) is alfo a weapon of war much employed in the countries of Hindoftan, combining with the miffile power of the javelin the impulfe of gun-powder. From the force and irregularity of its motion, the rocket is not eafily avoided, and, when thrown in numbers, it often makes very confiderable havock in an army. It confifts of a tube of iron, about eight inches long, and an inch and a half in diameter, clofed at one end: it is filled in the fame way as an ordinary fky-rocket, and fixed to a piece of ftout bamboo, from three to five feet long, the head of which is armed with a heavy iron fpike. At the extremity of the tube, which points towards the fhaft of the weapon, is the match; and the man who ufes it, placing the butt end of the bamboo upon his foot, points the fpiked end in the direction of the object to which he means to throw it, and fetting fire to the fuze, pitches it from him, when it flies with great velocity; and, on ftriking the ground by a bounding horizontal motion, acts with an almoft certain effect in fracturing the legs of the enemy. When a fhower of rockets falls among a body of cavalry, it feldom fails to throw them into confufion.

RODNEY (Lord). In our fhort fketch of the life of that gallant officer (*Encycl.*), we mentioned with regret our not having heard of any monument being erected to his honour in his native conntry. We have fince learned that there is a pillar upon the Brythen in Shropfhire, which was erected to his memory long before the publication of our article.

Having this great man again under our notice, we infert with pleafure the following extract of a letter, which we received from an obliging correfpondent foon after the publication of the volume which contains our biographical fketch of the Admiral: "Whatever were Rodney's merits as a naval commander (fays our correfpondent), there is a more brilliant part of his character which you have entirely neglected. Prior to his fuccefs againft the Spanifh Admiral Don Langara, the Englifh, who had the misfortune to become prifoners of war to the Spaniards, were treated with the greateft inhumanity, and it required more than a common ftrength of conftitution to exift for any length of time in a Spanifh prifon. When the Spanifh admiral fell into the hands of Rodney, he, his officers and feamen, expected to meet with the fame treatment they had always inflicted, and which they would have inflicted on Rodney, his officers, and feamen, had the Spaniards been the victors; but, to their furprife, they found in Admiral Rodney (and, of courfe, in all that were under his command) a man who fympathifed in their misfortune, who minifted to their neceffities, and by a humane and polite behaviour to his prifoners, made an impreffion on the minds of the Spaniards, which could not but have its effect in mitigating the fufferings of the

the Engliſh in Spaniſh priſons: but he did not ſtop here: he took an opportunity, when their minds were expanded by gratitude (and in a ſtate to receive the full force of ſuch a repreſentation), to repreſent to them the miſerable condition of his countrymen who were priſoners in Spain, and obtained a promiſe (which, I believe, was punctually performed), that Engliſhmen, when priſoners in Spain, ſhould be made as comfortable as their ſituation would admit of. This was a piece of ſervice to his country which ſurely merits to be recorded, and which will exalt him as much in the opinion of good men as the moſt brilliant diſplay of *courage*, which is a quality as frequently diſcovered in the ſavage as in the cultivated mind."

ROEBUCK (John, M. D.), was born at Sheffield in Yorkſhire in the year 1718. His father was a conſiderable manufacturer and exporter of Sheffield goods, who by his abilities and induſtry had acquired a competent fortune. John, his eldeſt ſon, the ſubject of this memoir, was intended by his father for carrying on his own lucrative buſineſs at Sheffield; but was, from his early youth, irreſiſtibly attached to other purſuits, more calculated to gratify his ambition, and give fuller play to his powers. Notwithſtanding this diſappointment in his favourite object, his father had liberality enough to encourage his riſing genius, and to give him all the advantages of a regular education.

After he had gone through the uſual courſe of the grammar ſchool at Sheffield, both his father and mother being ſtrict diſſenters, they placed their ſon for ſome years under the tuition of the late Dr Doddridge, who was at that time maſter of an academy at Northampton, and had juſtly acquired high reputation among the diſſenters, both as a divine and as an inſtructor of youth. Under the Doctor's care Mr Roebuck made great proficiency, and laid the foundation of that claſſical taſte and knowledge for which he was afterwards eminently diſtinguiſhed. It would appear that Dr Doddridge had been much pleaſed with the ardour and enthuſiaſm, in the purſuit of knowledge, diſcovered by his pupil; for Mr Roebuck, in an after period of his life, uſed frequently to mention the ſubjects of converſation and inquiries of various kinds, in which the Doctor had engaged him. It was during his reſidence at this academy that he contracted an intimate acquaintance with his fellow-ſtudents, Mr Jeremiah Dyſon, afterwards much known in the political world, and Mr Mark Akenſide, afterwards Dr Akenſide, which terminated only with their lives.

From the academy at Northampton he was ſent to the univerſity of Edinburgh, where he applied to the ſtudy of medicine, and particularly to that of chemiſtry, which about that time began to attract ſome attention in Scotland. While he reſided there he diſtinguiſhed himſelf much among his fellow-ſtudents, in their literary ſocieties and converſations, by great logical and metaphyſical acuteneſs, and by great ingenuity and reſource in argumentation. The late ſagacious Dr Potterfield, to whom he had been introduced, obſerved and encouraged his riſing genius, and was greatly inſtrumental in promoting his improvement. There, too, he formed an intimate acquaintance with Mr Hume, Mr Robertſon, afterwards Dr Robertſon, Mr Pringle, afterwards Lord Alemoor, and ſeveral other perſons of literary eminence; a circumſtance which produced in his mind a partiality ever afterwards in favour of Scotland, and contributed not a little to his making choice of it for the chief field of his future exertions and induſtry.

After Mr Roebuck had gone through a regular courſe of medical education at Edinburgh, being now determined to follow the practice of phyſic, he next ſpent ſome time at the univerſity of Leyden, then in high reputation as the firſt ſchool of medicine in Europe. There, after the uſual reſidence and courſe of trials, he obtained a degree in medicine; and his diploma, dated 21ſt February 1743, has affixed to it the reſpectable names of Muſchenbroek, Oſterdyk, Van Royen, Albinus, Gaubius, &c. He left Leyden, after having viſited ſome part of the north of Germany, about the end of the year.

Soon after his return from the continent, ſome circumſtances induced Dr Roebuck to ſettle as a phyſician at Birmingham. Before that time, Birmingham had begun to make a rapid progreſs in arts, manufactures, and population; and by the death of an aged phyſician, an opening was preſented to him, which afforded an immediate proſpect of encouragement in that line. His education, talents, and intereſting manners, were well calculated to promote his ſucceſs as a phyſician. He accordingly met there, at a period more early than he expected, with great encouragement; and was ſoon diſtinguiſhed, in that town and the country adjacent, for his ſkill, integrity, and charitable compaſſion, in the diſcharge of the duties of his profeſſion.

It appeared, however, ſoon after his reſidence was fixed at Birmingham, that his ſtudies and induſtry were turned to various objects beſides thoſe of his profeſſion. Strongly attached to the riſing ſcience of chemiſtry, he conceived high views of extending its uſefulneſs, and of rendering it ſubſervient to the improvement of arts and manufactures. With this view he fitted up a ſmall laboratory in his own houſe, in which he ſpent every moment of his time which he could ſpare from the duties of his profeſſion. There, in the true ſpirit of his great maſter Lord Bacon, of whoſe philoſophy he was an ardent admirer, he carried on various chemical proceſſes of great importance, and laid the foundation of his future projects on well-tried and well-digeſted experiments.

The firſt efforts of his genius and induſtry, thus directed, led him to the diſcovery of certain improved methods of refining gold and ſilver, and particularly to an ingenious method of collecting the ſmaller particles of theſe precious metals, which had been formerly loſt in the practical operations of many of the manufacturers. By other chemical proceſſes, carried on about the ſame time in his little laboratory, he diſcovered alſo improved methods of making ſublimate hartſhorn, and ſundry other articles of equal importance. After having received full ſatisfaction from the experiments upon which ſuch diſcoveries and improvement were founded, he next digeſted a plan for rendering them beneficial to himſelf, and uſeful to the public. A great part of his time being ſtill employed in the duties of his profeſſion, he found it neceſſary to connect himſelf with ſome perſon in whom he could repoſe confidence, and who might be, in other reſpects, qualified to give him ſupport and aſſiſtance in carrying on his intended eſtabliſhments. With this view, he choſe as his aſſociate Mr Samuel Garbet of Birmingham; a gentleman well qualified, by his abilities, activity, and enterpriſing ſpirit,

rit, for bearing his part in their future undertakings. The firſt project was the eſtabliſhment of an extenſive laboratory at Birmingham, for the purpoſes above mentioned; which, conducted by Dr Roebuck's chemical knowledge, and Mr Garbet's able and judicious management, was productive of many advantages to the manufacturers of that place, and of ſuch emolument to themſelves, as contributed greatly to the boldneſs of their future projects. That laboratory has, ever ſince that time, continued at Birmingham, and is ſtill conducted by Mr Garbet. Dr Roebuck, long before his death, had given up his intereſt in it.

About this time, in 1747, the Doctor married Miſs Ann Roe of Sheffield, a lady of a great and generous ſpirit, whoſe temper and diſpoſition equally fitted her for enjoying the proſperous circumſtances of their early life, and for bearing her equal ſhare of thoſe anxieties and diſappointments in buſineſs which ſhaded, but did not obſcure, the later period of their lives.

Dr Roebuck's unremitted perſeverance in his chemical ſtudies, together with the ſucceſs that attended them, led him, ſtep by ſtep, to other reſearches of great public and private benefit.

The extenſive uſe of the vitriolic (ſulphuric) acid in chemiſtry, and the proſpect of its application to ſome of the mechanic arts, had produced a great demand for that article, and turned the attention of chemiſts to various methods of obtaining it. The late Dr Ward had obtained a patent for making it; and though the ſubſtances from which it might be obtained, as well as certain methods of obtaining it, had been known to others, and particularly pointed out by Lemery the Elder, and by Glauber, yet Dr Ward was the firſt, it is believed, who eſtabliſhed a profitable manufacture upon the diſcovery. Much, however, was wanting to render the acid of univerſal uſe in chemiſtry, and of extenſive utility in the arts, where great quantities of it were required. The price of it was high, ariſing from the great expence of the glaſs veſſels, which were made uſe of by Dr Ward in procuring it, and the frequent accidents to which they were liable in the proceſs.

Dr Roebuck had been for ſome time engaged in making experiments with a view to reduce the price, and at length diſcovered a method of preparing it, by ſubſtituting, in place of the glaſs veſſels formerly uſed, lead ones of a great ſize; which ſubſtitution, together with ſundry other improvements in different parts of the proceſs, completely effected his end.

After the neceſſary preparations had been made, Meſſrs Roebuck and Garbet eſtabliſhed a manufacture of the oil of vitriol at Preſtonpans, in Scotland, in the year 1749. This eſtabliſhment not a little alarmed Dr Ward, who attempted to defeat their plan, by taking out a patent for Scotland, in addition to the one he had formerly obtained. In this attempt he failed. Dr Roebuck's diſcovery was found not to come within the ſpecification of Dr Ward's patent.

The Preſtonpans company, convinced that patents are of little avail in preſerving the property of new inventions or diſcoveries, in conducting their vitriol works reſolved to have recourſe to the more effectual methods of concealment and ſecrecy. By that method they were enabled to preſerve the advantages of their ingenuity and induſtry for a long period of years, and not only ſerved the public at a much cheaper rate than had ever been done formerly, but, it is believed, they realized, in that manufacture, a greater annual profit from a ſmaller capital than had been done in any ſimilar undertaking. The vitriol work is ſtill carried on at Preſtonpans; but long before Dr Roebuck's death, he was obliged to withdraw his capital from it.

About this time Dr Roebuck was urged, by ſome of his friends, to leave Birmingham, and to ſettle as a phyſician in London, where his abilities might have had a more extenſive field of exertion. He had been early honoured with the acquaintance of the late Marquis of Rockingham, who, as a lover of arts, had frequently engaged him in chemical experiments at Rockingham-houſe. It was there, alſo, he became acquainted with the late Sir George Saville, and with ſeveral other perſons of rank and influence. His old friend and ſchool-fellow Mr Dyſon, too, by this time, had acquired conſiderable name and influence, and preſſed him much to take that ſtep. Under ſuch patronage, and with the energy of ſuch talents as Dr Roebuck poſſeſſed, there could be little doubt of his ſoon arriving at an eminent rank as a phyſician in London. But the chemical concerns, with which he was at that time deeply occupied, holding out to him a proſpect of a richer harveſt, determined him to give up the practice of medicine altogether, and to fix his reſidence for the greateſt part of the year in Scotland.

The ſucceſs of the eſtabliſhment at Preſtonpans, which had far exceeded their expectation, enabled the Doctor and his partner Mr Garbet to plan and execute other works of ſtill greater benefit and public utility. In the proſecution of his chemical ſtudies and experiments, Dr Roebuck had been led to beſtow great attention on the proceſſes of ſmelting iron-ſtone, and had made ſome diſcoveries, by which that operation might be greatly facilitated, particularly by uſing pit-coal in place of charcoal. Mr William Caddell of Cockenzie, in the neighbourhood of Preſtonpans, a gentleman earneſtly intent upon promoting manufactures in Scotland, had, for ſeveral years, laboured, without much ſucceſs, in eſtabliſhing a manufacture of iron; a circumſtance which may have probably contributed to turn Dr Roebuck's attention more particularly to that ſubject. As the capital which he and his partner Mr Garbet could appropriate for carrying on the iron manufacture was not equal to ſuch an undertaking, and chiefly depended upon the profits of their other works, their firſt intention was to attempt a ſmall eſtabliſhment of that kind in the vicinity of their vitriol works at Preſtonpans. But the flattering proſpects of ſucceſs, ariſing from a courſe of experiments which Dr Roebuck had lately made, encouraged them to extend their plan, and to project a very extenſive manufactory of iron. A ſufficient capital was ſoon procured, through the confidence which many of their friends repoſed in their abilities and integrity. In fact, the eſtabliſhment which they made, or rather the capital which gave it exiſtence, was the united capital of a band of relations and friends, who truſted to Dr Roebuck and Mr Garbet the management of a great part of their fortune. When all previous matters had been concerted reſpecting their intended eſtabliſhment, the chief exertions of chemical and mechanical ſkill, neceſſary in the execution, were expected from Dr Roebuck. It fell to his ſhare alſo to fix upon the beſt and moſt favourite ſituation for erecting their intended works. With that view Dr Roebuck examined many different places in Scotland, particularly thofe on both fides of the Frith of Forth; and after a careful and minute comparifon of their advantages and difadvantages, he at length made choice of a fpot on the banks of the river *Carron* as the moft advantageous fituation for the eftablifhment of the iron manufacture. There he found they could eafily command abundance of water for the neceffary machinery; and in the neighbourhood of it, as well as everywhere both along the north and fouth coafts of the Frith, were to be found inexhauftible quarries of ironftone, limeftone, and coal. From Carron, alfo, they could eafily tranfport their manufactures to different countries by fea. The communication with Glafgow at that time by land carriage, which opened up to them a ready way to the American market, was fhort and eafy.

Many other things, that need not be here enumerated, fell to Dr Roebuck's fhare in preparing and providing for the introduction of this new manufacture into Scotland, particularly with refpect to the planning and erection of the furnaces and machinery. To infure fuccefs in that department, nothing was omitted which ability, induftry, and experience could fuggeft. With this view, he called to his affiftance Mr Smeaton, then by far the firft engineer in England. It was from him he received plans and drawings of the water-wheels and blowing apparatus, which, notwithftanding all the mechanical improvements which have been made fince, remain unrivalled in any of the other iron-works erected in Britain. This was the firft introduction of Mr Smeaton into Scotland, and was the occafion of various other difplays of the fkill and experience of that celebrated engineer in that part of the ifland. With the fame view, and to the fame effect, in a future period of his operations, he employed Mr James Watt, then of Glafgow, and had the merit of rendering that inventive genius, in the mechanical arts, better known both in this country and in England.

The neceffary preparations for the eftablifhment of the iron works at Carron were finifhed in the end of the year 1759; and on the 1ft January 1760 the firft furnace was blown; and in a fhort time afterwards a fecond was erected.

No period of Dr Roebuck's life required from him more vigorous and laborious exertions than that of the eftablifhment of the Carron works, and the firft trials of the furnaces and machinery. His family and friends remember well the ardour and intereft which he difcovered; the inceffant labour and watchfulnefs which he exerted on that occafion. Every thing was untried, the furnaces, the machinery, the materials, the workmen; the novelty of the undertaking in that country, its extent and difficulty, and the great ftake at iffue, were circumftances that muft have occafioned much ferious thought and anxiety to the partner, upon the credit of whofe knowledge and experience the work had been undertaken. But the Doctor had great powers and great refources; and the firft trial gave fufficient indications of future fuccefs.

For fome time after the eftablifhment of the Carron works, Dr Roebuck continued to give his attention and affiftance in the general management and fuperintendance of them, and with him all meafures of future operations were concerted. During this period, fome alterations of great importance were fuggefted by him, and carried into effect. By carefully obferving the progrefs of fmelting in the furnaces, at firft worked by bellows, befides their being fubject to various accidents, the Doctor difcovered the neceffity of rendering the blaft both ftronger and more equable; and propofing, as a problem to Mr Smeaton, the beft method of effecting that end, that celebrated engineer foon gave the plan of a blaft by three or four cylinders, which was afterwards tried, and fucceeded even beyond expectation.

When the bufinefs at Carron funk by degrees into a matter of ordinary detail, and afforded lefs fcope for the Doctor's peculiar talents, he was unfortunately tempted to engage in a new and different undertaking; from the failure of which he fuffered a reverfe of fortune, was deprived of the advantages refulting from his other works, and during the remainder of his life became fubjected to much anxiety and difappointment.

The eftablifhment of the Carron works, and the intereft Dr Roebuck had in their fuccefs, had naturally turned his attention to the ftate of coal in the neighbourhood of that place, and to the means of procuring the extraordinary fupplies of it which the iron-works might in future require. With the view, therefore, of increafing the quantity of coal worked in that neighbourhood, by an adventure which he thought would alfo turn out to his own emolument, he was induced to become leffee of the Duke of Hamilton's extenfive coal and falt works at Borrowftounnefs. The coal there was reprefented to exift in great abundance, and underftood to be of fuperior quality; and as Dr Roebuck had made himfelf acquainted with the moft improved methods of working coal in England, and then not practifed in Scotland, he had little doubt of this adventure turning out beneficial and highly lucrative. In this, however, he was cruelly difappointed. The opening of the principal ftratum of coal required much longer time, and much greater expence, than had been calculated; and, after it was opened, the perpetual fucceffion of difficulties and obftacles which occurred in the working and raifing of the coal, was fuch as has been feldom experienced in any work of that kind. The refult was, that after many years of labour and induftry, there were funk in the coal and falt works at Borrowftounnefs, not only his own, and the confiderable fortune brought him by his wife, but the regular profits of his more fuccefsful works; and along therewith, what diftreffed him above every thing, great fums of money borrowed from his relations and friends, which he was never able to repay; not to mention that, from the fame caufe, he was, during the laft twenty years of his life, fubjected to a conftant fucceffion of hopes and difappointments, to a courfe of labour and drudgery ill fuited to his tafte and turn of mind, to the irkfome and teafing bufinefs of managing and ftudying the humours of working colliers. But all thefe difficulties his unconquerable and perfevering fpirit would have overcome, if the never-ceafing demands of his coal works, after having exhaufted the profits, had not alfo compelled him to withdraw his capital from all his different works in fucceffion; from the refining work at Birmingham, the vitriol work at Preftonpans, the iron-works at Carron, as well as to part with his intereft in the project of improving the fteam-engine, in which he had

Roebuck. had become a partner with Mr Watt, the original inventor, and from which he had reafon to hope for future emolument.

It would be painful to mention the unhappy confequences of this ruinous adventure to his family and to himfelf. It cut off for ever the flattering profpect which they had of an independent fortune, fuited to their education and rank in life. It made many cruel encroachments upon the time and occupations of a man whofe mind was equally fitted to enjoy the high attainments of fcience, and the elegant amufements of tafte. As the price of fo many facrifices, he was only enabled to draw from his colliery, and that by the indulgence of his creditors, a moderate annual maintenance for himfelf and family during his life. At his death, his widow was left without any provifion whatever for her immediate or future fupport, and without the fmalleft advantage from the extraordinary exertions and meritorious induftry of her hufband.

Dr Roebuck had, fome years before his death, been attacked by a complaint that required a dangerous chirurgical operation. That operation he fupported with his ufual fpirit and refolution. In a fhort time he was reftored to a confiderable fhare of his former health and activity; but the effects of it never entirely left him, and feveral flighter returns of the complaint gradually impaired his conftitution. He ftill, however, continued, till within a few weeks of his death, to vifit his works, and to give direction to his clerks and overfeers. He was confined to his bed only a few days; and died on the 17th July 1794, retaining to the laft all his faculties, his fpirit and good humour, as well as the great intereft which he took, as a man of fcience and reflection, in the uncommon events which the prefent age has exhibited.

From a man fo deeply and fo conftantly engaged in the detail of active bufinefs, many literary compofitions were not to be expected. Dr Roebuck left behind him many *works*, but few *writings*. The great object which he kept invariably in view was to promote arts and manufactures, rather than to eftablifh theories or hypothefes. The few effays which he left, enable us to judge of what might have been expected from his talents, knowledge, and boldnefs of invention, had not the active undertakings in which, from an early period of life, he was engaged, and the fatiguing details of bufinefs, occupied the time for ftudy and inveftigation. A comparifon of the heat of London and Edinburgh, read in the Royal Society of London June 29, 1775; experiments on ignited bodies, read there 16th Feb. 1776; obfervations on the ripening and filling of corn, read in the Royal Society of Edinburgh 5th June 1784—are all the writings of his, two political pamphlets excepted, which have been publifhed. The publication of the effay on ignited bodies was occafioned by a report of fome experiments made by the Comte de Buffon, from which the Comte had inferred, that *matter* is heavier when hot than when cold. Dr Roebuck's experiments, made with great accuracy before a committee of the Royal Society at London, feem to refute that notion.

It is the works and eftablifhments projected and executed by Dr Roebuck, with the immediate and more remote effects of them upon the induftry, arts, and manufacturers of Scotland, which urge a juft claim to the refpect and gratitude of his country. This tribute is more due from the difcerning part of mankind, as this Roebuck. fpecies of merit is apt to be overlooked by the bufy or the fuperficial, and to fail in obtaining its due reward. The circumftances of Dr Roebuck were, in this refpect, peculiarly hard: for though, moft certainly, the projector and author of new eftablifhments highly ufeful to his country, and every day becoming more fo, he was, by a train of unfortunate events, obliged to break off his connection with them, at an unfeafonable time, when much was yet wanting to their complete fuccefs: and thus he left others in the poffeffion, not only of the lucrative advantages now derived from them, but even in fome meafure of the general merit of the undertaking, to a confiderable part of which he had the moft undoubted claim.

The eftablifhment of the laboratory at Birmingham in the year 1747, the firft public exhibition of Dr Roebuck's chemical talents, was, at that particular period, and in the ftate of the arts and manufactures at that time, highly beneficial, and fubfervient to their future progrefs: and the continuance and fuccefs of it, in that place, is a proof of the advantages which many of the manufacturers receive from it. Much had already been done, and many improvements made in arts and manufactures, chiefly by the fuggeftions of that ingenuity and experience which, in the detail of bufinefs, might be expected from the practical artift. Dr Roebuck was qualified to proceed a ftep farther; to direct experience by principles, and to regulate the mechanical operation of the artift by the lights of fcience. The effects of that eftablifhment extended, in a particular manner, to all that variety of manufactures in which gold and filver were required, to the preparing of materials, the fimplifying of the firft fteps, to the faving of expence and labour, and to the turning to fome account what had been formerly loft to the manufacturer. It is well known that, while Dr Roebuck refided at Birmingham, fuch was the opinion formed of his chemical knowledge and experience by the principal manufacturers, that they ufually confulted him on any new trial or effort to improve their feveral manufactures; and when he left that place, they fincerely regretted the lofs of that eafy and unreferved communication they had with him on the fubjects of their feveral departments.

On account of fimilar circumftances, the benefit to the public, from the eftablifhment of the vitriol works at Preftonpans, in the extention and improvement of many of the arts, cannot now be exactly afcertained. The vitriolic acid is one of the moft active agents in chemiftry, and every difcovery which renders it cheap and acceffible to the chemift muft be greatly fubfervient to the progrefs of that fcience. By the eftablifhment at Preftonpans, the price of that valuable acid was reduced from fixteen to four pence *per* pound. It is to Dr Roebuck, therefore, that chemifts are indebted for being in poffeffion of a cheap acid, to which they can have recourfe in fo many proceffes.

But Dr Roebuck's object in the profecution of that fcheme, was not fo much to facilitate the chemift's labour, as to render that acid, in a much higher degree than it had formerly been, fubfervient to many of the practical arts. By rendering the vitriolic acid cheap, great ufe came to be made of it in preparing the muriatic acid, and Glauber's falts from common falts. Its ufe

Roebuck. use has been farther extended to many metallic processes; and it has lately been employed in separating silver from the clippings of plated copper, the use of which is very extensive.

The project and establishment, however, of the iron-works at Carron, the most extensive establishment of that kind hitherto in Britain, must be considered as Dr Roebuck's principal work. The great and increasing demand for iron in the progressive state of arts, manufactures, and commerce in Britain, and the great sums of money sent every year to the north of Europe for that article, turned the attention of chemists and artists to the means of promoting the manufacture of iron, with the view of reducing the importation of it. No person has a better founded claim to merit, in this particular, than Dr Roebuck. The smelting of iron by pitcoal, it is indeed believed, had been attempted in Britain in the beginning of the last century. In the reign of James I. several patents seem to have been granted for making hammered iron by pitcoal, particularly to the Hon. Dud Dudley and Simon Starlevant. It does not appear, however, that any progress had been made in the manufacture in consequence of these patents. In later times trials have been made by so many different persons, and in so many different places in England, nearly about the same time, that it may be difficult to say where and by whom the first attempt was made, particularly as the discoverers of such processes wished to conceal the knowledge they had gained as long as they could. But Dr Roebuck was certainly among the first who, by means of pitcoal, attempted to refine crude or pig iron, and to make bar iron of it, instead of doing it by charcoal, according to the former practice: And he was, without all question, the person who introduced that method into Scotland, and first established an extensive manufacture of it. It is not meant to ascribe to him the sole merit of the establishment at Carron. No man was ever more ready than he was to do justice to the abilities and spirit of his friends and partners Messrs Garbet, Caddell, &c. who first embarked with him in that great undertaking. But still it may be said with truth, that the original project of the iron-works at Carron, the chemical knowledge and experience on which they were founded, the complicated calculations which were previously required, the choice of the situation, the general conduct and direction of the buildings and machinery, the suggestion of many occasional improvements, together with the removal of many unforeseen obstacles and difficulties, which occurred in the infant state of that establishment, were, in a great measure, the work and labour of Dr Roebuck, Nor can it, with the least shadow of justice, detract from his merit, that a larger capital, and greater expence than was at first calculated, have been found necessary to bring the works at Carron to their present state of perfection; or, that great alterations and improvements have taken place, during the course of forty years, in a great and progressive establishment. In all works of that kind, the expence exceeds the calculation. The undertakers even of the latest iron-works which have been erected, notwithstanding all the advantages obtained from recent experience, will be ready to acknowledge, that, in these respects, there is little room to blame the original projector of the first establishment of that kind in Scotland. But the best, and most infallible proof of Dr Roebuck's merit, and of the sound principles on which these works were established, is the present prosperous state of that establishment, the great perfection of many branches of their manufactures, and particularly the many extensive and flourishing iron-works which have since been erected upon the model of Carron in different parts of Scotland, at Cleugh, Clyde, Muirkirk, and Devon. It cannot be denied that all these works have sprung from the establishment at Carron, and are ultimately founded upon the knowledge and experience which have been obtained from them; for some of the partners, or overseers of these new works, and many of the workmen, have been, at one time or another, connected with that of Carron. Hence, then, it is owing to the projector and promoter of the establishment at Carron, that Scotland is, at this moment, benefited to the amount of many hundred thousand pounds, in working up the raw materials of that manufacture found in the country itself, and which, previous to that establishment, was of no value whatever. Such are the *present*, but scarcely any idea can be formed of the *future*, advantages to this country, which may be derived from the extension of the iron manufacture. About 60,000 tons of iron have been annually imported into Great Britain for more than twenty years past; and though there has been for some time about 20,000 tons of bar iron made in Britain by pitcoal, yet the foreign imported iron has suffered little or no diminution in quantity. This great consumption of iron, no doubt, is owing to the various improvements of late years, and the general extension throughout all Europe of commerce and the arts. The manufacture of iron must therefore continue to increase; and Scotland, abounding everywhere in ironstone, pitcoal, and in command of water for machinery, has the prospect of obtaining the largest share of it.

To the establishment of the Carron works, and to the consequences of that establishment, may be ascribed also the existence of other public works in Scotland of great importance and utility. The opening of a communication by water betwixt the Forth and the Clyde had long been projected, and frequently the subject of conversation in Scotland, but nothing in fact had been attempted. The establishment of the iron-works at Carron soon called forth sufficient interest and enterprise to bring about the execution of this grand design. Some of the partners of the Carron company, foreseeing the advantages they would derive from such a communication, proposed, at their own expence, to execute a small canal; and, after taking the preparatory steps, actually applied to Parliament to obtain authority for that purpose. But the project of the small canal not meeting with the approbation of some noblemen and gentlemen in that part of Scotland, they opposed the bill, and obliged themselves to execute a greater canal, which has now been many years finished, and is found to be of the greatest advantage to the trade and commerce of Scotland. The merit of this undertaking is not meant to be ascribed to Dr Roebuck, excepting in so far as it necessarily arose from the establishment of the Carron company, of which he was the original projector; and it may reasonably be doubted whether, without that establishment, it would have yet taken place.

place. Several other canals have since that time been executed in different parts of Scotland, and other very important ones are at present projected.

The different establishments which Dr Roebuck made at Borrowstounness in carrying on the coal and salt works there, though ultimately of no advantage to himself, were attended, during the course of thirty years, with the most beneficial effects upon the trade, population, and industry of that part of Scotland. They were the means also of adding very considerably to the public revenue. Previous to the time these works fell under Dr Roebuck's management, they produced no advantage either to the proprietor, to the adventurers, or to the public. But by his mode of conducting them upon a more extensive plan, by opening up new seams of coal, and of better quality, he was enabled to export a very considerable quantity, to increase the quantity of salt, and of course the revenue arising from these articles. In these works, and in the management of a large farm, Dr Roebuck gave employment to near a thousand persons at Borrowstounness and in the neighbourhood.

Nor was it solely by the different establishments which he projected and executed, but by many other things necessarily connected with them, that Dr Roebuck's labours were beneficial to Scotland. Along with them he may be said to have introduced a spirit of enterprise and industry, before that time little known in Scotland, which soon pervaded many other departments of labour, and gave birth to many other useful projects. He brought from England, then much farther advanced in arts and industry, many ingenious and industrious workmen, at great expence, who, by their instructions and example, communicated and diffused skill and knowledge to others. At all times Dr Roebuck held out liberal encouragement to rising genius and industrious merit; and spared no expence in making trials of improvements and discoveries which were connected with the different projects and works which he was carrying on.

Such was the active and useful life of Dr Roebuck, a man of no common cast, who united, in a very high degree, a great number of solid and brilliant talents, which, even separately, fall to the lot of but few individuals. Distinguished by an ardent and inventive mind, delighting in pursuit and investigation, always aspiring at something beyond the present state of science and art, and eagerly pressing forward to something better or more perfect, he thus united energies the most powerful with the most unwearied and persevering industry. To that peculiarity of imagination, so fitted for scientific pursuit, which readily combines and unites, which steadily preserves its combinations before the eye of the mind, and quickly discovers relations, results, and consequences, was added, in his character, great promptitude and firmness in decision. Strongly and early impressed with the great importance of applying chemical and physical knowledge to the useful arts, to the melioration of civil life, he never lost sight of that favourite view, and discovered great boldness and resource in the means and expedients which he adopted to promote it. He was certainly master of the best philosophy of chemistry known in the earlier parts of his life; and though in every stage of that science he marked and understood the progress of the discoveries, yet his numerous avocations did not permit him to follow them out by experimental processes of his own. Upon that, and indeed almost upon every subject, his mind readily grasped the most useful and substantial points, and enabled him to throw out such hints and hypotheses as marked him the man of genius.

During the course of a regular education, both at Edinburgh and at Leyden, Dr Roebuck studied the classic authors with great attention, particularly the historical and political parts of their works. Upon these subjects he had read much, selected with judgment, and was well acquainted with the facts and philosophy of ancient governments. This taste he carried with him, and improved in every period of his life, and in every situation. It abundantly rewarded him for the earnestness and diligence with which it had been acquired. It became his favourite resource, and indeed one of the chief enjoyments of his life. Possessing the happy talent of turning his mind from serious and fatiguing, to elegant and recreating pursuits, it was no uncommon thing with him to return from the laboratory or the coalpit, and draw relaxation or relief from some one or other of the various stores of classical learning.

No man was better acquainted with the history of his country than Dr Roebuck, or more admired and revered the constitution of its government. By temper and education he was a Whig, and at all times entered with great warmth into the political disputes and controversies which agitated parties in the different periods of his life. If the natural warmth of his temper, and his enthusiasm on these subjects, led him, on some occasions, beyond the bounds of candid argumentation, his quick sense of decorum, and his perfect habits of good manners, produced an immediate atonement, and restored the rights of elegant and polished conversation.

The general acquaintance which Dr Roebuck had acquired with natural and experimental philosophy, together with his classical and political knowledge, rendered him an agreeable companion to the learned almost of every department, and procured him the attachment and friendship of many of the first literary characters in Britain. With his friend Dr Black he lived till his death in close habits of intimacy; and he often acknowledged, with much frankness, the advantages which he derived in his various pursuits, from a free and unreserved communication with that eminent chemist.

The amiable dispositions of sensibility, humanity, and generosity, which strongly marked his character in the general intercourse of society, were peculiarly preserved and exercised in the bosom of his family, and in the circle of his friends. In the various relations of husband, father, friend, or master, and in the discharge of the respective duties arising from them, it would not be easy to do justice to his character, or to determine in which of them he most excelled; nor must it be forgot, for it reflected much honour on his benevolent heart, that his workmen not only found him at all times a kind and indulgent master; but many of them, when their circumstances required it, a skilful and compassionate physician, who cheerfully visited the humblest recesses of poverty, and who attached them to his service by multiplied acts of generosity and kindness.

ROEMER (Olaus), a noted Danish astronomer and mathematician, was born at Arhusan in Jutland, 1644; and at 18 years of age was sent to the university of

Roemer, Rollock.

of Copenhagen. He applied assiduously to the study of the mathematics and astronomy, and became so expert in those sciences, that when Picard was sent by Louis the XIV. in 1671, to make observations in the north, he was greatly surprised and pleased with him. He engaged him to return with him to France, and had him presented to the king, who honoured him with the dauphin as a pupil in mathematics, and settled a pension upon him. He was joined with Picard and Cassini, in making astronomical observations; and in 1672 he was admitted a member of the Academy of Sciences.

During the ten years he resided at Paris, he gained great reputation by his discoveries; yet it is said he complained afterwards, that his coadjutors ran away with the honour of many things which belonged to him. Here it was that Roemer, first of any one, found out the velocity with which light moves, by means of the eclipses of Jupiter's satellites. He had observed for many years, that when Jupiter was at his greatest distance from the earth where he could be observed, the emersions of his first satellite happened constantly 15 or 16 minutes later than the calculation gave them. Hence he concluded, that the light reflected by Jupiter took up this time in running over the excess of distance; and consequently that it took up 16 or 18 minutes in running over the diameter of the earth's orbit, and 8 or 9 in coming from the sun to us, provided its velocity was nearly uniform. This discovery had at first many opposers; but it was afterwards confirmed by Dr Bradley in the most ingenious and beautiful manner.

In 1681 Roemer was recalled to his native country by Christian the Vth King of Denmark, who made him professor of astronomy at Copenhagen. The king employed him also in reforming the coin and the architecture, in regulating the weights and measures, and in measuring and laying out the high roads throughout the kingdom; offices which he discharged with the greatest credit and satisfaction. In consequence he was honoured by the king with the appointment of chancellor of the exchequer and other dignities. Finally, he became counsellor of state, and burgomaster of Copenhagen, under Frederic the IV. the successor of Christian. Roemer was preparing to publish the result of his observations, when he died the 19th of September 1710, at 66 years of age: but this loss was supplied by Hurrebow, his disciple, then professor of astronomy at Copenhagen, who published, in 4to, 1753, various observations of Roemer, with his method of observing, under the title of *Basis Astronomiæ*.—He had also printed various astronomical observations and pieces, in several volumes of the Memoirs of the Royal Academy of Sciences at Paris, of the institution of 1666, particularly vol. 1. and 10. of that collection.

ROLLOCK (Robert), the first principal of the college of Edinburgh, was the son of David Rollock of *Pouhouse*, or, as it is now written, *Powis*, in the neighbourhood of Stirling. He was born in 1555; and learned the rudiments of the Latin tongue under one Mr Thomas Buchanan, who kept, says Archbishop Spottiswood, a famous school at that time, and was, according to Dr Mackenzie, one of the most eminent grammarians in Scotland. Where Mr Buchanan kept his school, neither of these authors has informed us.

From school Mr Rollock was sent, we know not in what year, to the university of St Andrews, and admitted a student in St Salvator's college. His progress in the sciences, which were then taught, was so great and so rapid, that he had no sooner taken his degree of M. A. than he was chosen a professor of philosophy, and immediately began to read lectures in St Salvator's college. This must have been at a very early period of life; for he quitted St Andrews in the year 1583, when, according to Mackenzie, he had taught philosophy for some time in that university.

Rollock.

Not long before this period, the magistrates of Edinburgh having petitioned the king to erect a university in that city, he granted them a charter under the great seal, allowing them all the privileges of a university; and the college being built in 1582, they made choice of Mr Rollock to be their principal and professor of divinity.

At what time he was admitted into holy orders, by whom he was ordained, or indeed whether he ever was ordained, has been the subject of some acrimonious controversy; but it is a controversy which we shall not revive; for, considering the manner in which orders were then conferred in Scotland, the question in debate is of very little importance. It is certain that he became famous in the university, and among his countrymen in general, for his lectures in theology, and for the persuasive power of his preaching; for Calderwood assures us, that, in 1589, he and Mr Robert Bruce, another popular orator, made the Earl of Bothwel so sensible of his sinful and vitious courses, that, upon the 9th of November, his lordship humbled himself upon his knees in the east church in the forenoon, and in the high church in the afternoon, confessing before the people, with tears in his eyes, his dissolute and licentious life, and promising to prove, for the future, another man.

In the year 1593, Principal Rollock and others were appointed by the states of parliament to confer with the popish lords; and in the next year he was one of those who, by the appointment of the general assembly of the church, met at Edinburgh in the month of May, and presented to his majesty a paper, entitled, *The dangers which, through the impunity of* EXCOMMUNICATED PAPISTS, TRAFFICKERS WITH THE SPANIARDS, *and other enemies of the religion and estate, are imminent to the true religion professed within this realm, his Majesty's person, crown, and liberty of this our native country.* His zeal against Papists was indeed ardent; and he seems to have adopted that judaical doctrine, which was embraced in some degree by all the reformers, that it is the duty of the civil magistrate to punish idolatry with death.

In the year 1595 he was nominated one of the commissioners for the visitation of colleges. These commissioners were empowered to visit all the colleges in the kingdom, to inquire into the doctrine and life of the several masters, the discipline used by them, the state of their rents and living, and to make their report to the next assembly.

In 1596, the factious behaviour of some of the ministers having drawn upon them the just resentment of the king, our principal was employed, on account of his moderation, to soften that resentment, and to turn his majesty's wrath against the *Papists!* In the year 1597, he was chosen moderator of the General Assem-

Rollock.

bly—the higheft dignity in the Scottifh church; and he had the influence to get fome great abufes redreffed. Being one of fourteen minifters appointed by this affembly to take care of the affairs of the church, the firft thing which he did was to procure an act of the legiflature, reftoring to the prelates their feats in parliament. He had here occafion for all his addrefs; for he had to reconcile to this meafure, not only fuch of the minifters as abhorred all kinds of fubordination in the church, but likewife many of the lay lords, who were not delighted with the profpect of fuch affociates in parliament as the Scotch prelates were at that period (A).

Though he fpent the greater part of his life in conducting the affairs of the church, we have the authority of Spottifwood for faying, that he would have preferred retirement and ftudy. To the buftle of public life, efpecially at that period of faction and fanaticifm, his feeble conftitution was not equal; and his inclination would have confined him to his college and his library. He was dreadfully afflicted with the ftone; the torments of which he long bore with the fortitude and refignation of a Chriftian. He died at Edinburgh on the 28th of February 1598, in the 43d year of his age; having exhorted his brethren, with his dying-breath, to carry themfelves more dutifully to their gracious fovereign.

His works are, 1. A Commentary on the Firft Book of Theodore Beza's Queftions. 2. A Commentary on St Paul's Epiftle to the Ephefians, 4to, Edinburgh, 1590. 3. A Commentary on the Prophet Daniel, 4to, Edinburgh, 1591. 4. A Logical Analyfis of St Paul's Epiftle to the Romans, 8vo, Edinburgh, 1594. 5. Some Queftions and Anfwers concerning the Covenant of Grace and the Sacraments, 8vo, Edinburgh, 1596. 6. A Treatife of Effectual Calling, 8vo, Edinburgh, 1597. 7. A Commentary on the Epiftles of St Paul to the Theffalonians and Philemon, 8vo, Geneva, 1597. 8. A Commentary upon Fifteen Select Pfalms, 8vo, Geneva, 1598. 9. A Commentary on the Gofpel of St John, with a harmony of the Four Evangelifts upon the Death, Refurrection, and Afcenfion of Jefus Chrift, 8vo, Geneva, 1599. 10. Certain Sermons on Several Places of St Paul's Epiftles, 8vo, Edinburgh, 1598. 11. A Commentary upon the Epiftle to the Coloffians, 8vo, publifhed at Geneva, 1602. 12. A Logical Analyfis of the Epiftle to the Hebrews, 8vo, Edinburgh, 1605. 13. A Logical Analyfis of the Epiftle to the Galatians, 8vo, London, 1602. 14. A Commentary upon the Two Firft Chapters of the Firft Epiftle of St Peter, 8vo, London, 1603. 15 and 16. A Treatife of Juftification, and another of Excommunication, both in 8vo, London, 1604. All thefe works, except the fermons, are in Latin. That Principal Rollock was held in high eftimation in the college over which he prefided, is made at leaft probable by the following epitaph:

Rofes, Rota.

Te Rolloce, extincto, Urbs mœfta, Academia mœfta eft;
Et tota exequiis Scotia mœfta tuis.
Uno in te nobis dederat Deus omnia, in uno
Te Deus eripuit omnia quæ dederit.

ROSES OTTER (or effential oil) OF. In the *Encyclopædia*, under the word ROSES, we have given one receipt for making this very high-priced perfume; and we fhall here give another; which, whether it be as effectual or not, is at leaft fimpler and lefs expenfive. It is by an officer who was in the country where the *Otter* is prepared, and who affifted in making it himfelf; and is as follows:

"Take a very large glazed earthen or ftone jar, or a large clean wooden cafk; fill it with the leaves of the flowers of rofes, very well picked, and freed from all feeds and ftalks; pour on them as much pure fpring water as will cover them, and fet the veffel in the fun, in the morning at fun-rife, and let it ftand till the evening, then take it into the houfe for the night; expofe it, in this manner, for fix or feven fucceffive days, and, at the end of the third or fourth day, a number of particles, of a fine yellow oily matter, will float on the furface, which, in two or three days more, will gather into a fcum, which is the otter of rofes. This is taken up by fome cotton, tied to the end of a piece of ftick, and fqueezed with the finger and thumb into a fmall phial, which is immediately well ftopped; and this is repeated for fome fucceffive evenings, or while any of this fine effential oil rifes to the furface of the water."

Dr Donald Monro, who communicated this receipt to the Royal Society of Edinburgh, fays, that he has been informed, that fome few drops of this effential oil have more than once been collected by diftillation in London, in the fame manner as the effential oils of other plants.

ROTA ARISTOTELICA, or *Ariftotle's Wheel*, denotes a celebrated problem in mechanics, concerning the motion or rotation of a wheel about its axis; fo called becaufe firft noticed by Ariftotle.

The difficulty is this. While a circle makes a revolution on its centre, advancing at the fame time in a right line along a plane, it defcribes, on that plane, a right line which is equal to its circumference. Now if this circle, which may be called the deferent, carry with it another fmaller circle, concentric with it, like the nave of a coach wheel; then this little circle, or nave, will defcribe a line in the time of the revolution, which fhall be equal to that of the large wheel or circumference

(A) The conftitution of the Scotch church was, at this period, a ftrange fyftem of inconfiftency and contradiction. It was, in fact, prefbyterian; for ecclefiaftical difcipline was adminiftered then, as at prefent, by kirkfeffions, prefbyteries, and general affemblies; and there was not a reformed bifhop in the kingdom. Whether provincial fynods were then in ufe, the writer of this note does not at prefent recollect. The king, however, who was meditating the reftoration of epifcopacy, conferred the eftates, or part of the eftates, belonging to the different fees, upon the moft eminent parochial minifters, and dignified them with the title of bifhops; though it does not appear that they had any jurifdiction over their brethren; and though they were certainly not *ex officio* fo much as moderators of the prefbyteries within the bounds of which their churches were fituated. Thefe were the men for whom Mr Rollock exerted himfelf to obtain feats in the parliament.

cumference itfelf; becaufe its centre advances in a right line as faft as that of the wheel does, being in reality the fame with it.

The folution given by Ariftotle, is no more than a good explication of the difficulty.

Galileo, who next attempted it, has recourfe to an infinite number of infinitely little vacuities in the right line defcribed by the two circles; and imagines that the little circles never applies its circumference to thofe vacuities; but in reality only applies it to a line equal to its own circumference; though it appears to have applied it to a much larger. But all this is nothing to the purpofe.

Tacquet will have it, that the little circle, making its rotation more flowly than the great one, does on that account defcribe a line longer than its own circumference; yet without applying any point of its circumference to more than one point of its bafe. But this is no more fatisfactory than the former.

After the fruitlefs attempts of fo many great men, M Dortous de Meyran, a French gentleman, had the good fortune to hit upon a folution, which he fent to the Academy of Sciences; where, being examined by Meffrs de Louville and Soulman, appointed for that purpofe, they made their report that it was fatisfactory. The folution is to this effect:

The wheel of a coach is only acted on, or drawn in a right line; its rotation or circular motion arifes purely from the refiftance of the ground upon which it is applied. Now this refiftance is equal to the force which draws the wheel in the right line, inafmuch as it defeats that direction; of confequence the caufes of the two motions, the one right and the other circular, are equal. And hence the wheel defcribes a right line on the ground equal to its circumference.

As for the nave of the wheel, the cafe is otherwife. It is drawn in a right line by the fame force as the wheel; but it only turns round becaufe the wheel does fo, and can only turn in the fame time with it. Hence it follows, that its circular velocity is lefs than that of the wheel, in the ratio of the two circumferences; and therefore its circular motion is lefs than the rectilinear one. Since then it neceffarily defcribes a right line equal to that of the wheel, it can only do it partly by fliding and partly by revolving, the fliding part being more or lefs as the nave itfelf is fmaller or larger.—*Hutton's Dictionary*.

ROWNING (John), an ingenious Englifh mathematician and philofopher, was fellow of Magdalen College, Cambridge, and afterwards Rector of Anderby in Lincolnfhire, in the gift of that Society. He was a conftant attendant at the meetings of the Spalding Society, and was a man of a great philofophical habit and turn of mind, though of a cheerful and companionable difpofition. He had a good genius for mechanical contrivances in particular. In 1738 he printed at Cambridge, A Compendious Syftem of Natural Philofophy, in 2 vols 8vo; a very ingenious work, which has gone through feveral editions. He had alfo two pieces inferted in the Philofophical Tranfactions, viz. 1. A Defcription of a Barometer, wherein the Scale of Variation may be increafed at pleafure; vol. xxxviii. p. 39. And, 2. Directions for making a Machine for finding the Roots of Equations univerfally, with the Manner of ufing it; vol. lx. p. 240.—Mr Rowning died at his lodgings in Carey ftreet, near Lincoln's-Inn Fields, the latter end of November 1771, at 72 years of age.

Though a very ingenious and pleafant man, he had but an unpromifing and forbidding appearance: he was tall, ftooping in the fhoulders, and of a fallow, downlooking countenance.

ROY ROYAN, in Bengal, the chief officer in the revenue department, next to the Dewan under the native government.

RUTHERFORD (John, M. D.), one of the illuftrious founders of the medical fchool in the univerfity of Edinburgh, was the fon of the Rev. Mr Rutherford minifter of Yarrow, in the county of Selkirk, North Britain. He was born on the 1ft Auguft 1695, and received the rudiments of his education at the parifh fchool of Selkirk. where, from his future proficiency, there is every reafon to believe that he made a rapid progrefs in the knowledge of the Latin and Greek languages.

After the death of his father, he went to Edinburgh in 1708 or 1710, where, in the univerfity, he applied himfelf to the ftudy of claffical literature, mathematics, and natural philofophy. The celebrated Dr Pitcairn was then fo highly refpected for his medical fkill, that it is not improbable but that a laudable defire of obtaining a portion of fimilar fame may have turned the attention of young Rutherford to the ftudy of medicine. Be that as it may, he engaged himfelf apprentice to Mr Alexander Nefbit, at that time an eminent furgeon in Edinburgh, with whom he remained till 1716, when he went to London. There he attended fome hofpitals, and the lectures read on anatomy by Dr Douglas, on furgery by André, and on materia medica by Strother.

After a year's refidence in London, he returned to Edinburgh; and having fettled his affairs in that city, he went to Leyden, which, from the lectures of Boerhaave, was then the moft celebrated medical fchool in Europe. In 1719 he went into France, and was at the end of July in that year admitted to the degree of M. D. in the univerfity of Rheims. He paffed the following winter in Paris, chiefly for the fake of Winflow's private demonftrations in anatomy; and in 1720 he returned to Britain.

In 1721 he fettled as a phyfician in Edinburgh; and foon afterwards Drs Rutherford, Sinclair, Plummer, and Innes, purchafed a laboratory, where they prepared compound medicines. This was an art then but little known in Scotland; and as a commercial fpeculation, the laboratory muft therefore have proved very advantageous to the partners. But they had higher objects in view than commerce. They demonftrated, as far as they were then known, the operations of chemiftry to a numerous audience; and foon afterwards, by the advice of their old mafter Boerhaave, they extended their lectures to the other branches of phyfic. In 1725 they were appointed joint profeffors in the univerfity; where, we believe, each, for fome time, read lectures in every department of medical fcience, anatomy excepted, and carried forward their claffes in rotation. The anatomical lectures were read by the elder Monro, who had been fettled a year or two before them in Edinburgh, and whofe eminence in that department is known to all Europe.

On the death of Dr Innes, a particular branch of medical ſcience was allotted to each of the other three profeſſors. Dr Plummer was appointed profeſſor of chemiſtry and materia medica, Dr Sinclair of the inſtitutes of phyſic, and Dr Rutherford of the practice; and thus was a regular medical ſchool eſtabliſhed in Edinburgh by Monro, Plummer, Sinclair, and Rutherford. The lectures on the inſtitutes and practice of phyſic were then, and for many years afterwards, delivered in Latin; and ſuch was Dr Rutherford's command of that language, that on every thing connected with medicine, he talked in it more fluently than in the language of his country.

Whether it was any improvement in the mode of medical education in Edinburgh to change the language of the lectures from Latin to Engliſh, is perhaps more than queſtionable. We have now diſperſed over the country a number of illiterate men, practiſing as ſurgeons, and even as phyſicians, who never could have boaſted of having gone through a regular courſe of medical inſtruction, had the lectures continued to be delivered in the language in which they were begun. Foreigners, too, would not have been under the neceſſity of learning a new language, before they could enter on the ſtudies, for the cultivation of which they came to Scotland; and though the medical claſſes might not have been ſo crowded perhaps as at preſent, the individuals compoſing them would have been at leaſt as reſpectable. Whether Dr Rutherford reaſoned in this way we know not; but he continued to lecture in Latin as long as he filled the practical chair.

About the year 1748 he introduced a very great improvement in the courſe of medical education. Senſible that abſtract lectures on the ſymptoms and the mode of treating various diſeaſes, of which the ſtudents know little but the names, could ſcarcely be of any benefit, he had for ſome time encouraged his pupils to bring patients to him on Saturday, when he inquired into the nature of their diſeaſes, and preſcribed for them in the preſence of the claſs. This gave riſe to the courſe of *clinical* lectures; the utility of which was ſo obvious, that it was enacted, by a decree of the ſenate of the univerſity, that no man ſhould be admitted to an examination for his doctor's degree, who had not attended thoſe lectures; to which an excellent hoſpital, then lately erected (ſee EDINBURGH, in the *Encyclopædia*), gave the profeſſors every opportunity of doing ample juſtice. To men who mean to live by the practice of phyſic, and have no inordinate ambition to raiſe their fame by fanciful theories, this is perhaps the moſt valuable courſe of lectures that is given in Edinburgh; and if ſo, Dr Rutherford muſt be conſidered as one of the greateſt benefactors of the medical ſchool.

To untried theories in phyſic he was indeed no friend; and we have heard a favourite and very able pupil of his, who knew him well, and reſpected him highly, affirm that, to his knowledge, Dr Rutherford retained his profeſſorſhip longer than he otherwiſe would have choſen to do; merely that he might keep out a ſpeculatiſt, whom he knew to be aſpiring to the practical chair. Finding at laſt in the late Dr John Gregory (ſee GREGORY, *Encycl.*) a ſucceſſor entirely to his mind, he reſigned to him in 1765, after having taught medicine in its different departments for upwards of forty years. He lived, after this period, loved by his friends, and revered by many eminent phyſicians, who had been his pupils, till 1779, when he died in Edinburgh, where he had ſpent the greater part of his life, in the 84th year of his age.

S.

SACCHAROMETER, the name given, by Mr Richardſon of Hull, to an inſtrument invented by him for aſcertaining the value of worts, and the ſtrength of different kinds of malt liquors. In plain Engliſh, the name ſignifies a *meaſurer of ſweetneſs*; and therefore, if etymology were to be attended to, the inſtrument ſhould be employed merely as a meaſurer of the ſweetneſs of worts. It is in fact beſt adapted for this purpoſe, being merely an hydrometer contrived to aſcertain the ſpecific gravity of worts, or rather to compare the weight of worts with that of equal quantities of the water employed in the brewery where the inſtrument is uſed.

The principle which ſuggeſted the invention of the inſtrument to Mr Richardſon is as follows: The menſtruum or water, employed by the brewer, becomes heavier or more denſe by the addition of ſuch parts of the materials as have been diſſolved or extracted by, and thence incorporated with it: the operation of boiling, and its ſubſequent cooling, ſtill adds to the denſity of it by evaporation; ſo that when it is ſubmitted to the action of fermentation, it is more denſe than at any other period.

In paſſing through this operation of nature, a remarkable alteration takes place. The fluid no ſooner begins to ferment than its denſity begins to diminiſh; and as the fermentation is more or leſs perfect, the fermentable matter, whoſe acceſſion has been traced by the increaſe of denſity, becomes more or leſs attenuated; and in lieu of every particle thus attenuated, a ſpirituous particle, of leſs denſity than water, is produced: ſo that when the liquor is again in a ſtate of quietude, it is ſo much ſpecifically lighter than it was before, as the action of fermentation has been capable of attenuating the component parts of its acquired denſity; and, indeed, were it practicable to attenuate the whole, the liquor

liquor would become lighter or lefs denfe than water; becaufe the quantity of fpirit produced from, and occupying the place of the fermentable matter, would diminifh the denfity of the water in a degree bearing fome proportion to that in which the latter had increafed it.

From thefe facts, the reader, who is acquainted with hydroftatical principles, will be able to conftruct a faccharometer for himfelf. Brewers who are ftrangers to thefe principles, we muft refer to Mr Richardfon's book for details, which our limits permit us not to give.

SAGITTA, in aftronomy, the *Arrow* or *Dart*; a conftellation of the northern hemifphere near the eagle, and one of the 48 old afterifms.

SAHARA, or, as it is fometimes written, ZAARA, the Great Defert, is a vaft ocean of fand in the interior parts of Africa, which, with the leffer deferts of Bornou, Bilma, Barca, Sort, &c. is equal in extent to about one half of Europe. If the fand be confidered as the ocean, the Sahara has its gulphs and bays, as alfo its iflands, or OASES, fertile in groves and paftures, and in many inftances containing a great population, fubject to order and regular government.

The great body, or weftern divifion of this ocean, comprized between Fezzan and the Atlantic, is no lefs than 50 caravan journeys acrofs, from north to fouth; or from 750 to 800 G. miles; and double that extent in length: without doubt the largeft defert in the world. This divifion contains but a fcanty portion of iflands (or oafes), and thofe alfo of fmall extent: but the eaftern divifion has many, and fome of them very large. Fezzan, Gadamis, Taboo, Ghanat, Agadez, Augela, Berdoa, are amongft the principal ones: befides which, there are a vaft number of fmall ones. In effect, this is the part of Africa alluded to by Strabo, when he fays from *Cneius Pifo*, that Africa may be compared to a leopard's fkin.

From the beft inquiries that Mr Park could make when a kind of captive among the Moors at Ludamar, the Weftern Defert, he fays, may be pronounced almoft deftitute of inhabitants; except where the fcanty vegetation, which appears in certain fpots, affords pafturage for the flocks of a few miferable Arabs, who wander from one well to another. In other places, where the fupply of water and pafturage is more abundant, fmall parties of the Moors have taken up their refidence. Here they live, in independent poverty, fecure from the tyrannical government of Barbary. But the greater part of the defert, being totally deftitute of water, is feldom vifited by any human being; unlefs where the trading caravans trace out their toilfome and dangerous route acrofs it. In fome parts of this extenfive wafte, the ground is covered with low ftunted fhrubs, which ferve as land-marks for the caravans, and furnifh the camels with a fcanty forage. In other parts, the difconfolate wanderer, wherever he turns, fees nothing around him but a vaft interminable expanfe of fand and fky; a gloomy and barren void, where the eye finds no particular object to reft upon, and the mind is filled with painful apprehenfions of perifhing with thirft. Surrounded by this dreary folitude, the traveller fees the dead bodies of birds, that the violence of the wind has brought from happier regions; and, as he ruminates on the fearful length of his remaining paffage, liftens with horror to the voice of the driving blaft; the only found that interrupts the awful repofe of the defert.

The few wild animals which inhabit thefe melancholy regions, are the antelope and the oftrich; their fwiftnefs of foot enabling them to reach the diftant wateringplaces. On the fkirts of the defert, where the water is more plentiful, are found lions, panthers, elephants, and wild boars.

Of domeftic animals, the only one that can endure the fatigue of croffing the defert is the camel. It is therefore the only beaft of burden employed by the trading caravans which traverfe, in different directions, from Barbary to Nigritia. The flefh of this ufeful and docile creature, though to our author's tafte it was dry and unfavoury, is preferred by the Moors to all others. The milk of the female, he fays, is in univerfal efteem, and is indeed pleafant and nutritive.

That the defert has a dip towards the eaft as well as the fouth, feems to be proved by the courfe of the Niger. Moreover, the higheft points of North Africa, that is to fay, the mountains of Mandinga and Atlas, are fituated very far to the weft. The defert, for the moft part, abounds with falt. But we hear of falt mines only in the part contiguous to Nigritia, from whence falt is drawn for the ufe of thofe countries, as well as of the Moorifh ftates adjoining; there being no falt in the Negro countries fouth of the Niger. There are falt lakes alfo in the eaftern part of the defert.

SAI, a large town on the banks of the Niger, or at leaft very near to that river, which Mr Park fays ftrongly excited his curiofity. It is completely furrounded by two very deep trenches, at about two hundred yards diftant from the walls. On the top of the trenches are a number of fquare towers; and the whole has the appearance of a regular fortification. Inquiring into the origin of this extraordinary entrenchment, our author learned from two of the town's people the following particulars; which, if true, furnifh a mournful picture of the enormities of African wars:

About fifteen years before our traveller vifited Sai, when the King of Bambarra defolated Maniana, the Dooty of Sai had two fons flain in battle, fighting in the king's caufe. He had a third fon living; and when the king demanded a further reinforcement of men, and this youth among the reft, the Dooty refufed to fend him. This conduct fo enraged the king, that when he returned from Maniana, about the beginning of the rainy feafon, and found the Dooty protected by the inhabitants, he fat down before Sai with his army, and furrounded the town with the trenches which had attracted our author's notice. After a fiege of two months, the town's people became involved in all the horrors of famine; and whilft the king's army were feafting in their trenches, they faw with pleafure the miferable inhabitants of Sai devour the leaves and bark of the Bentang tree that ftood in the middle of the town. Finding, however, that the befieged would fooner perifh than furrender, the king had recourfe to treachery. He promifed, that if they would open the gates, no perfon fhould be put to death, nor fuffer any injury, but the Dooty alone. The poor old man determined to facrifice himfelf, for the fake of his fellow-citizens, and immediately walked over to the king's army, where he was put to death. His fon, in attempting to efcape, was caught and maffacred in the trenches; and the reft of the town's people were carried away captives, and fold as flaves to the different Negro-traders.

traders. Sai is placed by Major Rennel in 14° N. Lat. and 3° 7′ W. Long.

SAINT CATHERINE, a Portuguese island in the South Sea, not far distant from the coast of Brazil. It was visited by La Perouse, who ascertained it to lie between 27° 19′ 10″, and 27° 49′ N. Lat. and its most northerly point to be in 49° 49′ longitude west from Paris. Its breadth from east to west is only two leagues; and it is separated from the main land by a channel only 200 toises broad. On the point which stretches furthest into this channel is situated the city of Nostra Senora del Destero, the capital of the government, and the place of residence of the governor. It contains at most 3000 souls, and about 400 houses. Its appearance is exceedingly pleasant. According to Frezier's account, this island served, in 1712, as a retreat to vagabonds, who made their escape from different parts of the Brazils; who were only nominal subjects of Portugal, and who acknowledged no authority whatever. The country is so fertile, that they were able to subsist without any succour from the neighbouring colonies: and they were so destitute of money, that they could neither tempt the cupidity of the governor-general of the Brazils, nor inspire him with any desire of subduing them. The ships that touched at the island gave them in exchange for their provisions nothing but clothes and shirts, of which they were in the utmost want. It was not till about 1740 that the court of Lisbon established a regular government in the island of St Catherine, and the parts of the continent adjacent. This government extends sixty leagues north and south from the river San Francisco to Rio Grande; its population being about 20,000 souls; but there are so great a number of children in the different families, that probably it will soon be much more considerable. The soil is exceedingly fertile, and produces all sorts of fruit, vegetables, and corn, almost spontaneously. It is covered with trees of everlasting green; but they are so interwoven with briars and creeping plants, that it is impossible to get through the forests otherwise than by opening a path with a hatchet. Danger is besides to be apprehended from snakes, whose bite is mortal. The habitations, both on the island and continent, are all close to the sea side. The woods that surround them are delightfully fragrant, owing to the great number of orange trees and other odoriferous trees and shrubs that they contain. But, notwithstanding all these advantages, the country is very poor, and totally destitute of manufactured commodities, so that the peasants are almost naked, or else covered with rags. Their soil, which is very fit for the cultivation of sugar, remains unproductive for the want of slaves, whom they are not rich enough to purchase. The whale fishery is very successful; but it is the property of the crown, and is farmed by a company at Lisbon, which has three considerable establishments upon the coast. Every year they kill about 400 whales; the produce of which, as well oil as spermaceti, is sent to Lisbon by the way of Rio Janeiro. The inhabitants are idle spectators of this fishery, from which they derive not the smallest advantage. La Perouse gives a very amiable picture, however, of their hospitality to strangers.

SALT. See CHEMISTRY-*Index*, in this *Suppl.*

SALT-Mines of Vielicza, near Cracow in Poland, are very extraordinary caverns; for a description of which we referred, in the article SALT (*Encycl.*) to M. Barniard in the *Journal de Physique* for the year 1786. Some of our readers have complained of this, and requested an account of them in the *Supplement*. With this request we shall comply, by giving them Mr Wraxall's description of these caverns*.

"After being let down (says he) by a rope to the depth of 230 feet, our conductors led us through galleries, which, for loftiness and breadth, seemed rather to resemble the avenues to some subterranean palace, than passages cut in a mine. They were perfectly dry in every part, and terminated in two chapels composed entirely of salt, hewn out of the solid mass. The images which adorn the altars, as well as the pillars and ornaments, were all of the same transparent materials; the points and spars of which, reflecting the rays of light from the lamps which the guides held in their hands, produced an effect equally novel and beautiful. Descending lower into the earth by means of ladders, I found myself in an immense hall or cavern of salt, many hundred feet in height, length, and dimensions, the floor and sides of which were cut with exact regularity. A thousand persons might dine in it without inconvenience, and the eye in vain attempted to trace or define its limits. Nothing could be more sublime than this vast subterranean apartment, illuminated by flambeaux, which faintly discover its prodigious magnitude, and leave the imagination at liberty to enlarge it indefinitely. After remaining about two hours and a half under ground, I was drawn up again in three minutes with the greatest facility."

* *Memoirs of the Courts of Berlin, Dresden, Warsaw, and Vienna.*

SALTPETRE (see *Nitre*, CHEMISTRY-*Index*, in this *Suppl.*) is an article of so much importance, and sometimes so difficult to be had, that it is wonderful more attention is not bestowed in endeavouring to discover some easy method to increase the quantity. Such a method has been long practised by the farmers of Appenzell in Switzerland. In so hilly a country, most houses and stables are built on slopes, one side of the edifice resting on the hill, and the other being supported by two strong posts, elevated two or three feet above the ground; so that the air has a free current under the building. Immediately under the stable a pit is dug, usually occupying both in breadth and length the whole space of ground covered by the building; and instead of the clayey earth which is dug out, the pit is filled up with sandy soil. This is the whole process, and all the rest is done by Nature. The animal water, which is continually oozing through the planks of the floor, having drenched the earth contained in the pit for the space of two or three years, the latter is emptied, and the saltpetre is refined and prepared in the usual manner.

That manner, however, is not the best; and the French chemists, during the incessant wars occasioned by the revolution, have, for the sake of supplying their armies with gunpowder, turned their attention to the best method of refining saltpetre. The following are directions given for this purpose by Chaptal, Champy, and Bonjour.

The crude saltpetre is to be beaten small with mallets, in order that the water may more easily attack every part of the mass. The saltpetre is then to be put into tubs, five or six hundred pounds in each tub. Twenty *per cent.* of water is to be poured into each tub, and

and the mixture well ftirred. It muft be left to macerate or digeft until the fpecific gravity of the fluid ceafes to augment. Six or feven hours are fufficient for this firft operation, and the water acquires the denfity of between 25 and 35 degrees. Sp. gr. 1.21, and 1.306, afcertained by Baumé's hydrometer. See HYDROMETER, *Suppl.*

The firft water muft then be poured off, and a fecond portion of water muft be poured on the fame faltpetre, amounting to 10 *per cent.*; after which the mixture muft be ftirred up, fuffered to macerate for one hour, and the fluid drawn or poured off.

Five *per cent.* of water muft then be poured on the faltpetre; and after ftirring the whole, the fluid muft be immediately drawn off.

When the water is drained from the faltpetre, the falt muft be thrown into a boiler containing 50 *per cent.* of boiling water. When the folution is made, it will mark between 66 and 68 degrees of the hydrometer. (Sp. gr. 1.848, and 1.898.)

The folution is to be poured into a proper veffel, where it depofits by cooling about two-thirds of the faltpetre originally taken. The precipitation begins in about half an hour, and terminates in between four and fix hours. But as it is of importance to obtain the faltpetre in fmall needles, becaufe in this form it is more eafily dried, it is neceffary to agitate the fluid during the whole time of the cryftallization. A flight motion is communicated to this liquid mafs by a kind of rake; in confequence of which the cryftals are depofited in very flender needles.

In proportion as the cryftals fall down, they are fcraped to the borders of the veffel, whence they are taken with a fkimmer, and thrown to drain in bafkets placed on treffels, in fuch a manner that the water which paffes through may either fall into the cryftallizing veffel, or be received in bafons placed underneath.

The faltpetre is afterwards put into wooden veffels in the form of a mill-hopper or inverted pyramid with a double bottom. The upper bottom is placed two inches above the lower on wooden ledges, and has many fmall perforations through which water may pafs to the lower bottom, which likewife affords a paffage by one fingle aperture. A refervoir is placed beneath. The cryftallized faltpetre is wafhed in thefe veffels with 5 *per cent.* of water; which water is afterwards employed in the folution of faltpetre in fubfequent operations.

The faltpetre, after fufficient draining, and being dried by expofure to the air upon tables for feveral hours, may then be employed in the manufacture of gunpowder.

But when it is required to ufe the faltpetre in the fpeedy and immediate manufacture of gunpowder, it muft be dried much more ftrongly. This may be effected in a ftove, or more fimply by heating it in a flat metallic veffel. For this purpofe the faltpetre is to be put into the veffel to the depth of five or fix inches, and heated to 40 or 50 degrees of the thermometer (or about 135° of Fahrenheit). The faltpetre is to be ftirred for two or three hours, and dried fo much that, when ftrongly preffed in the hand, it fhall acquire no confiftence, nor adhere together, but refemble a very fine dry fand. This degree of drynefs is not required when the powder is made by pounding.

From thefe circumftances, we find that two faline liquids remain after the operations; (1) the water from the wafhing; and (2) that from the cryftallizing veffels.

We have already remarked, that the wafhing of the faltpetre is performed in three fucceffive operations, in which, upon the whole, the quantity of fluid made ufe of amounts to 35 *per cent.* of the weight of the crude faltpetre. Thefe wafhings are eftablifhed on the principle, that cold water diffolves the muriats of foda, and the earthy nitrats and muriats, together with the colouring principle, but fcarcely attacks the nitrat of potafh.

The water of thefe three wafhings therefore contains the muriat of foda, the earthy falts, the colouring principle, and a fmall quantity of nitrat of potafh; the amount of which is in proportion to that of the muriat of foda, which determines its folution.

The water of the cryftallizing veffels contains a portion of the muriats of foda, and of the earthy falts which efcaped the operation of wafhing, and a quantity of nitrat of potafh, which is more confiderable than that of the former folution.

The waters made ufe of at the end of the operation, to whiten and wafh the cryftals depofited in the pyramidal veffel, contain nothing but a fmall quantity of nitrat of potafh.

Thefe waters are therefore very different in their nature. The water of the wafhings is really a mother water. It muft be collected in veffels, and treated with potafh by the known proceffes. It muft be evaporated to 66 degrees (or 1.848 fp. gr.), taking out the muriat of foda as it falls. This folution is to be faturated with 2 or 3 *per cent.* of potafh, then fuffered to fettle, decanted, and poured into cryftallizing veffels, where 20 *per cent.* of water is to be added to keep the whole of the muriat of foda fufpended.

The waters which are thus obtained by treatment of the mother water may be mixed with the water of the firft cryftallization. From thefe the marine falt may be feparated by fimple evaporation; and the nitrat of potafh, which they hold in folution, may be afterwards obtained by cooling.

The fmall quantity of water made ufe of to wafh and whiten the refined faltpetre, contains nothing but the nitrat of potafh: it may therefore be ufed in the folution of the falpetre when taken from the tubs.

From this defcription it follows, that a manufactory for the fpeedy refining of faltpetre ought to be provided with (1) mallets or rammers for pounding the faltpetre; (2) tubs for wafhing; (3) a boiler for folution; (4) a cryftallizing veffel of copper or lead, in which the faltpetre is to be obtained by cooling; (5) bafkets to drain the cryftals; (6) a wooden cafe or hopper for the laft wafhing and draining the faltpetre; (7) fcales and weights for weighing; (8) hydrometers and thermometers, to afcertain denfities and temperatures; (9) rakes to agitate the liquor in the cryftallizing veffel; (10) fkimmers to take out the cryftals, and to convey them to the bafkets; (11) fyphons or hand-pumps to empty the boilers.

The number and dimenfions of thefe feveral articles muft vary according to the quantity of faltpetre intended to be refined.

GUM-SANDARAC, is faid, in the *Encyclopædia*, to

Sandarac, Sanders.

to be produced from a ſpecies of juniper. This was long the common opinion; but M. Schouſboe has lately proved (A) it to be a miſtake. The *juniperus communis*, from which many have derived this gum, does not grow in Africa; and Sandarac ſeems to belong excluſively to that part of the world. The gum ſandarac of our ſhops is brought from the ſouthern provinces of the kingdom of Morocco. About ſix or ſeven hundred quintals of it are exported every year from Santa Cruz, Mogador, and Saſſy. In the language of the country it is called *el graſſa*. The tree which produces it is a *Thuia*, found alſo by M. Vahl in the kingdom of Tunis. It was made known ſeveral years ago by Dr Shaw, who named it *Cypreſſus fructu quadrivalvi, Equiſeti inſtar articulatis*; but neither of theſe learned men was acquainted with the economical uſe of this tree; probably becauſe, being not common in the northern part of Barbary, the inhabitants find little advantage in collecting the reſin which exudes from it.

M. Schouſboe, who ſaw the ſpecies of *thuia* in queſtion, ſays that it does not riſe to more than the height of twenty or thirty feet at moſt, and that the diameter of its trunk does not exceed ten or twelve inches. It diſtinguiſhes itſelf, on the firſt view, from the two other ſpecies of the ſame genus, cultivated in gardens, by having a very diſtinct trunk, and the figure of a real tree; whereas in the latter the branches riſe from the root, which gives them the appearance rather of buſhes. Its branches alſo are more articulated and brittle. Its flowers, which are not very apparent, ſhew themſelves in April; and the fruit, which are of a ſpherical form, ripen in September. When a branch of this tree is held to the light, it appears to be interſperſed with a multitude of tranſparent veſicles which contain the reſin. When theſe veſicles burſt in the ſummer months, a reſinous juice exudes from the trunk and branches, as is the caſe in other coniferous trees. This reſin is the ſandarac, which is collected by the inhabitants of the country, and carried to the ports, from which it is tranſported to Europe. It is employed in making ſome kinds of ſealing-wax, and in different ſorts of varniſh. In 1793 a hundred weight of it coſt in Morocco from 13 to 13½ piaſtres, which make from about L. 3, 5s. to L. 3, 7s. 6d. ſterling. The duty on exportation was about 7s. 6d. ſterling per quintal.

Sandarac, to be good, muſt be of a bright-yellow colour, pure and tranſparent. It is an article very difficult to be adulterated. Care, however, muſt be taken, that the Moors do not mix with it too much ſand. It is probable that a tree of the ſame kind produces the gum ſandarac of Senegal, which is exported in pretty conſiderable quantities.

SANDERS-RED (ſee PTEROCARPUS, *Encycl.*) is uſed as a dye-ſtuff, but generally in a manner which is very diſadvantageous. In Crell's Chemical Annals are given, by Mr Vogler, the following directions for dyeing with this wood.

1. Into a ſolution of tin made with aquafortis (nitric acid), and mixed with three times as much ſalt water, put clean waſhed wool, ſilk, linen, and cotton. After ſix hours, take them out, and waſh them carefully in three different quantities of clean cold water, wringing them well each time. Let them dry, and then put half the quantity of each article into the ſpirituous tincture of red ſanders, hereafter deſcribed in nº 6. letting them ſoak therein, without heat, from half an hour to an hour. To aſcertain the ſuperiority of his different proceſſes, the other half of each article muſt be boiled in the tincture of ſanders mixed with water, deſcribed in nº 7. a bare quarter of an hour. After being taken out, wrung, and dried in the ſhade, all of them will be dyed throughout of a fine rich poppy-colour.

2. Take three drams of powdered alum, and diſſolve it in twelve ounces of clean hot water. Into this ſolution, while yet warm, put ſome well-waſhed wool, ſilk, linen, and cotton. After ſuffering them to remain therein for the ſpace of twelve hours, take them out, waſh them well in three quantities of clean cold water (wringing them each time), and dry them. Then ſteep the half of each article in the cold ſpirituous tincture of ſanders (nº 6.), from half an hour to an hour; and boil the other half of each in the diluted tincture of ſanders (nº 7.) for the ſpace of ſix or ſeven minutes. After being taken out, wrung, and dried in the ſhade, they will be found to have acquired a very beautiful and rich ſcarlet colour.

3. Diſſolve three drams of blue vitriol, or vitriol of copper, in twelve ounces of hot water. Steep in this ſolution, for twelve hours, wool, ſilk, linen, or cotton; and having ſufficiently waſhed the ſtuff in clean cold water, immerſe the one half of it in the ſpirituous tincture of ſanders (nº 6.), from half an hour to an hour; and boil the other half of each for ſix or ſeven minutes in the diluted tincture, nº 7. Being then taken out, wrung, and dried in the ſhade, as before, they will have acquired a beautiful, rich, bright, crimſon colour.

4. Steep wool, ſilk, linen, and cotton, which has been well waſhed, during twelve hours, in a ſolution of three drams of white vitriol, or vitriol of zinc, in twelve ounces of hot water. After being taken out, well waſhed in clean cold water, and dried, immerſe one half of each in the cold ſpirituous tincture of ſanders (nº 6.) and boil the other half in the diluted tincture (nº 7.) as before. When taken out, wrung, and dried, they will be of a fine, rich, deep crimſon colour.

5. Diſſolve three drams of common green vitriol, or vitriol of iron, in twelve ounces of hot water: ſteep well-waſhed wool, ſilk, linen, and cotton, in the ſolution, for the ſpace of twelve hours. When taken out, waſhed ſeveral times in clean cold water, and dried, treat them, as in nº 4. and they will be generally found to be of a fine, rich, deep violet colour; though, on repeating his experiments, our author ſometimes found the colour a dark browniſh red.

The tincture in which the ſtuffs are to be died muſt be prepared in the following manner.

6. Take half an ounce of red ſanders wood, beat or ground to powder, as it is ſold at the colour ſhops or druggiſts. Having put it into a large glaſs bottle, pour upon it twelve ounces of malt ſpirit or common brandy; then cork the bottle, and ſet it in a moderately-warm place. In the ſpace of 48 hours, the ſpirit will have extracted all the colouring matter from the red ſanders, and thereby acquired a bright red colour. The bottle ſhould

(A) In a Daniſh Journal, intitled, *The Phyſical, Medical, and Economical Library*, Part III. 1799.

should be often shaken during the digestion; and the tincture, thus prepared, may be used for dyeing without heat, and without separating the powdered sanders from the liquor. The articles to be dyed (after the application of the proper mordants, n° 1, 2, 3, 4, 5) are to be steeped in the tincture for half an hour, or a whole hour: they are then to be taken out wrung, and dried in the shade. This tincture does not lose its dyeing quality by age; but dyes substances, after being kept a long time, almost as well as when it is just made. Its colouring power is indeed weakened by the frequent immersion and dyeing of different articles in it; and when that is the case, it must be again digested with some fresh sanders-wood.

7. Mix the spirituous tincture of sanders, just described, with from six to ten times as much clean cold water. The mixture was made by our author without any separation of the colouring particles worth noticing; and in this diluted tincture, the various articles (having their proper mordants first applied, n° 1, 2, 3, 4, 5) were boiled, as before mentioned. Linen and cotton, by being dipped in glue-water, after the application of the mordants, acquire, in this diluted tincture, a much deeper and richer colour.

If a very fine and bright colour be desired, the above spirituous tincture of sanders should not be too old, nor should the digestion be protracted beyond 48 hours; for after that period, the spirit appears to extract brown and yellow colouring particles from the wood. The powder of sanders need not be separated from the diluted tincture which is made use of by boiling; nor is it absolutely necessary to wash the articles in cold water after they are dyed; as the powder which adheres to them may easily be taken off by rubbing and shaking. M. Vogler, however, found it advantageous, after the articles were taken out of the dye, and wrung, to steep them for a few minutes in a cold solution of half an ounce of common salt, and a quarter of an ounce of alumn, in 12 ounces of pure water. In this case, they should afterwards be washed several times in clean cold water, then wrung and dried in the shade. By this method the colours are not only more beautiful, but are also more permanent. All the articles of wool, silk, linen, and cotton, which were dyed as is above mentioned, bore perfectly well the test of alkaline ley, soap, and acids; but, by exposure to the open air and the sun, the colours were more easily discharged, especially from linen and cotton.

N. B. Red sanders, by being ground to a fine powder, answers much better for dyeing by this process, than when it is merely cut into small pieces; but it must be remarked, that the powder of red sanders which is sold at the shops is sometimes adulterated, by being mixed with other substances, and moistened with acids. The best kind is not light, but rather heavy; and is not of a dark red colour, but clear and bright.

Goodwin SANDS, famous sand banks off the coast of Kent, lying between the north and south Foreland; and as they run parallel with the coast for three leagues together, at about two leagues and a half distant from it, they add to the security of that capacious road the Downs; for while the land shelters ships with the wind from south-west to north-west only, these sands break all the force of the sea when the wind is at east south-east. The most dangerous wind, when blowing hard on the Downs, is the south-south west. These sands occupy the space that was formerly a large tract of low ground belonging to Godwyn Earl of Kent, father of King Harold; and which being afterward given to the monastery of St Augustin at Canterbury, the abbot neglecting to keep in repair the wall that defended it from the sea, the whole tract was drowned, according to Salmon, in the year 1100, leaving these sands, upon which so many ships have since been wrecked.

SANSANDING, a town in Africa, situated near the banks of the Niger, in Lat. 14° 24′ N. and 2° 23′ W. Long. It is inhabited by Moors and Negroes to the number of from eight to ten thousand. The Negroes are kind, hospitable, and credulous; the Moors are at Sansanding, as every where else in the interior parts of Africa, fanatical, bigotted, and cruel.

SAP, or Sapp, in building, as to sap a wall, &c. is to dig out the ground from beneath it, so as to bring it down all at once for want of support.

SAPHAN, in zoology. See Mus, *Encycl.* p. 467.

SAPHIES, a kind of charms, consisting of some scrap of writing, which the credulous Negroes believe capable of protecting them from all evil. The writers of saphies are generally Moors, who sell scraps of the Koran for this purpose to a people who believe not either in the Koran or the prophet. Accordingly, any piece of writing may be sold as a saphie; and Mr Park found the Negroes disposed to place greater confidence in the saphies of a Christian than in those of a Moor. The manner in which these charms are supposed to operate, will be learned from the following story:

Mr Park being at Koolikorro, a considerable town near the Niger, and a great market of salt, his landlord, hearing that he was a Christian, immediately thought of procuring a saphie. For this purpose he brought out his *walha*, or writing board, assuring me (says our author) that he would dress me a supper of rice if I would write him a saphie to protect him from wicked men. The proposal was of too great consequence to me to be refused; I therefore wrote the board full, from top to bottom, on both sides; and my landlord, to be certain of having the whole force of the charm, washed the writing from the board into a calabash with a little water; and having said a few prayers over it, drank this powerful draught; after which, lest a single word should escape, he licked the board until it was quite dry. A saphie writer was a man of too great consequence to be long concealed: the important information was carried to the Dooty, who sent his son with half a sheet of writing-paper, desiring me to write him a *naphula saphie* (a charm to procure wealth). He brought me, as a present, some meal and milk; and when I had finished the saphie, and read it to him with an audible voice, he seemed highly satisfied with his bargain, and promised to bring me in the morning some milk for my breakfast. Our author contrived to turn this absurd superstition to his own advantage, by writing saphies for his subsistence when his money was exhausted.

SARACOLETS, a negro nation occupying the lands situated between the rivers of Senegal and Gambia. They are a laborious people, cultivate their lands with care, are plentifully supplied with all the necessaries of life, and inhabit handsome and well-built villages; their houses, of a circular form, are for the most part terraced;

ced; the others are covered with reeds as at Senegal; they are inclosed with a mud wall a foot thick, and the villages are surrounded with one of stone and earth of double that solidity. There are several gates, which are guarded at night for fear of a surprise. This nation is remarkably brave, and it is very uncommon to find a Saracolet slave. They always defend themselves with advantage against their assailants. Such Saracolets as are exposed to sale may be safely purchased, for (excepting when they are at war with the Poules) none are to be met with but such as have been condemned by the laws for some misdemeanour; in such case, these wretches could not escape slavery even by taking refuge in their own country; for they would be restored to their masters, or would be put to death, if the convey should have failed. The religious principles of this people are nearly allied to Mahometanism, and still more to natural religion. They acknowledge one God; and believe that those who steal, or are guilty of any crime, are eternally punished. They admit a plurality of wives, and believe their souls to be immortal like their own. They think lightly of adultery; for as they allow themselves several wives, they are not so unjust as to punish women who distribute their favours among several gallants; a mutual exchange is then permitted, one woman may be bartered for another, unless she be free, or a native of the country. In this last case, the French custom prevails; it is winked at, although the laws are particularly severe against the violation of the most sacred of all property. This nation lies near that of the Poules. (See that article, *Suppl.*) Its extent into the country is unknown; all that we know is, that it is governed by four powerful princes, all bearing the name of Fouquet. The least considerable, according to the testimony of the Saracolets, is that of Tuago, who can assemble thirty thousand horse, and whose subjects occupy a territory two hundred leagues in extent, as well on the Senegal as on the track that reaches beyond the Felou; a rock which, according to the same report, forms cataracts, from whence proceed the Senegal and the river Gambia, equally considerable.

SAROS, in chronology, a period of 223 lunar months. The etymology of the word is said to be Chaldean, signifying restitution, or return of eclipses; that is, conjunctions of the sun and moon in nearly the same place of the ecliptic. The Saros was a cycle like to that of Meto.

SARRASIN or SARRAZIN, in fortification, a kind of port-cullis, otherwise called a herse, which is hung with ropes over the gate of a town or fortress, to be let fall in case of a surprise.

SAVILLE (Sir Henry), a very learned Englishman, the second son of Henry Saville, Esq; was born at Bradley, near Halifax, in Yorkshire, November the 30th, 1549. He was entered of Merton college, Oxford, in 1561, where he took the degrees in arts, and was chosen fellow. When he proceeded master of arts in 1570, he read for that degree on the Almagest of Ptolemy, which procured him the reputation of a man eminently skilled in mathematics and the Greek language; in the former of which he voluntarily read a public lecture in the university for some time.

In 1578 he travelled into France and other countries; where, diligently improving himself in all useful learning, in languages, and the knowledge of the world, he became a most accomplished gentleman. At his return, he was made tutor in the Greek tongue to Queen Elizabeth, who had a great esteem and liking for him.

In 1585 he was made warden of Merton College, which he governed six-and-thirty years with great honour, and improved it by all the means in his power.—In 1596 he was chosen provost of Eton College; which he filled with many learned men.—James I. upon his accession to the crown of England, expressed a great regard for him, and would have preferred him either in church or state; but Saville declined it, and only accepted the ceremony of knighthood from the king at Windsor in 1604. His only son Henry dying about that time, he thenceforth devoted his fortune to the promoting of learning. Among other things, in 1619, he founded, in the University of Oxford, two lectures, or professorships, one in geometry, the other in astronomy; which he endowed with a salary of 160 l. a-year each, besides a legacy of 600 l. to purchase more lands for the same use. He also furnished a library with mathematical books, near the mathematical school, for the use of his professors; and gave 100 l. to the mathematical chest of his own appointing: adding afterwards a legacy of 40 l. a-year to the same chest, to the university, and to his professors jointly. He likewise gave 120 l. towards the new building of the schools, besides several rare manuscripts and printed books to the Bodleian library; and a good quantity of Greek types to the printing press at Oxford.

After a life thus spent in the encouragement and promotion of science and literature in general, he died at Eton College the 19th of February 1622, in the 73d year of his age, and was buried in the chapel there. On this occasion, the university of Oxford paid him the greatest honours, by having a public speech and verses made in his praise, which were published soon after in 4to, under the title of *Ultima Linea Savilii*.

As to the character of Saville, the highest encomiums are bestowed on him by all the learned of his time: by Casaubon, Mercerus, Meibomius, Joseph Scaliger, and especially the learned Bishop Montague; who, in his *Diatribæ* upon Selden's History of Tythes, styles him, "that magazine of learning, whose memory shall be honourable amongst, not only the learned, but the righteous for ever."

Several noble instances of his munificence to the republic of letters have already been mentioned; in the account of his publications many more, and even greater, will appear. These are,

1. Four Books of the Histories of Cornelius Tacitus, and the Life of Agricola; with Notes upon them, in folio, dedicated to Queen Elizabeth, 1581.—2. A View of certain Military Matters, or Commentaries concerning Roman Warfare, 1596.—3. *Rerum Anglicarum Scriptores post Bedam*, &c. 1598. This is a collection of the best writers of our English history; to which he added chronological tables at the end, from Julius Cæsar to William the Conqueror.—4. The Works of St Chrysostom, in Greek, in 8 vols folio, 1613. This is a very fine edition, and composed with great cost and labour. In the preface he says, "that having himself visited, about 12 years before, all the public and private libraries in Britain, and copied out thence whatever he thought useful to this design, he then sent some learned men into France, Germany, Italy,

Saville, Saussure.

Italy, and the East, to transcribe such parts as he had not already, and to collate the others with the best manuscripts." At the same time, he makes his acknowledgments to several eminent men for their assistance; as Thuanus, Valserus, Schottus, Casaubon, Ducæus, Gruter, Hoeschelius, &c. In the 8th volume are inserted Sir Henry Saville's own notes, with those of other learned men. The whole charge of this edition, including the several sums paid to learned men, at home and abroad, employed in finding out, transcribing, and collating the best manuscripts, is said to have amounted to no less than L. 8000. Several editions of this work were afterwards published at Paris.—5. In 1618 he published a Latin work, written by Thomas Bradwardin, archbishop of Canterbury, against Pelagius, intitled, *De Causa Dei contra Pelagium, et de virtute causarum;* to which he prefixed the life of Bradwardin.—6. In 1621 he published a collection of his own Mathematical Lectures on Euclid's Elements, in 4to.—7. *Oratio coram Elizabetha Regina Oxoniæ habita*, anno 1592. Printed at Oxford in 1458, in 4to. 8. He translated into Latin King James's Apology for the Oath of Allegiance. He also left several manuscripts behind him, written by order of King James; all which are in the Bodleian library. He wrote notes likewise upon the margin of many books in his library, particularly Eusebius's Ecclesiastical History; which were afterwards used by Valesius, in his edition of that work in 1659.—Four of his letters to Camden are published by Smith, among Camden's Letters, 1691, 4to.

SAUSSURE (Horace Benedict de) was born at Geneva in 1740. His father, an intelligent farmer, to whom we are indebted for some memoirs relating to rural economy, resided at Conches, a place situated on the banks of the Arve, at the distance of half a league from Geneva; and this country life, added to an active education, expanded no doubt in young De Saussure that physical strength so necessary to the naturalist who devotes himself to travel. He repaired daily to town to enjoy the advantage of public instruction; and as he lived at the bottom of Saleve, a mountain which he has since rendered celebrated, he amused himself frequently with ascending its steep and rugged sides. Being thus surrounded by the phenomena of nature, and at the same time aided by study, he conceived a taste for natural history, and avoided the error both of the learned, who form theories without having been out of their closets, and of those farmers who, living too near to Nature, are incapable of admiring her beauties.

His earliest passion was botany: a variegated soil, abundant in plants of different kinds, invites the inhabitant of the banks of the Leman to cultivate that agreeable science. This taste produced an intimacy between De Saussure and the great Haller. He paid him a visit in the year 1764, during his retreat to Bex; and he relates in his travels how much he admired that astonishing man, who excelled in every part of the natural sciences. De Saussure was induced also to study the vegetable kingdom, by his connection with Ch. Bonnet, who had married his aunt, and who soon set a just value on the rising talents of his nephew. Bonnet (See his life in this *Suppl.*) was then employed on the leaves of plants. De Saussure studied these organs of vegetables also, and he published the result of his researches, under the title of Observations on the Bark of Leaves. This small work, which appeared soon after the year 1760, contains new observations on the epidermis of leaves, and in particular on the miliary glands by which they are covered.

About that period, the place of professor of philosophy falling vacant, it was conferred upon De Saussure, who was then only twenty-one years of age. Experience proves, that if premature rewards extinguish the zeal of those who labour merely for themselves, they, on the contrary, strengthen it in those who labour only for truth. At that time the two professors of philosophy at Geneva taught physics and logic alternately. De Saussure discharged this double task with equal success. He gave to his course of logic a practical, and, as one may say, experimental turn; and his method of teaching, which began by studying the senses to arrive at the general laws of the understanding, announced already an able observer of nature.

Physics, however, were the part for which he had the greatest taste, and which conducted him to the study of chemistry and mineralogy. He then began his travels through the mountains; not now to examine their vegetable productions, but to study the mountains themselves, either in the stones of which they are composed, or the disposition of their masses. Geology, a science which was then scarcely in existence, added charms to his numerous excursions through the Alps; and it was then that the talents of the great philosopher were really displayed. During the first fifteen or twenty years of his professorship, he employed himself by turns in discharging the duties of his office, and in traversing the different mountains in the neighbourhood of Geneva. He even extended his excursions on one side as far as the banks of the Rhine, and on the other to Piedmont. At the same time he undertook a journey to Auvergne to examine there the extinguished volcanoes, and another to Paris, England, and Holland. After that he visited Italy, and even Sicily. These were not mere journeys for the purpose of reaching any particular place; he undertook them only with a view of studying nature; never travelled but surrounded by every instrument that could be of use to him, and never set out until he had drawn up a plan of the experiments and observations he intended to make. He often says in his works that he had found this method exceedingly useful.

In the year 1779 he published the first volume of his Travels through the Alps; which contains a minute description of the environs of Geneva, and an excursion as far as Chamouni, a village at the bottom of Mont Blanc. Philosophers will read there with pleasure the description of his Magnetometer. The more he examined mountains, the more was he sensible of the importance of mineralogy. To study it with advantage, he learned the German language; and it may be seen, in the last volumes of his Travels, how much new mineralogical knowledge he had acquired.

Amidst his numerous excursions through the Alps, and at the time of the political troubles of Geneva in 1782, he found means to make his beautiful experiments on hygrometry, which he published in 1783, under the title of *Essays on Hygrometry*. This work, the best that ever came from his pen, established fully his reputation as a philosopher. We are indebted to him also for the invention of a new hygrometer. Deluc had

Sauffure.

had already invented his whalebone hygrometer; and on that account there arofe between him and De Sauffure a fort of conteft, which degenerated into a pretty violent difpute.

In the year 1786 De Sauffure refigned the profeffor's chair, which he had filled for about twenty-five years, to his pupil and fellow-labourer Pictet, who difcharged with reputation the duties of an office rendered more difficult by fucceeding fo eminent a philofopher.

When De Sauffure was invited by the ftate to take a fhare in the public education, he made it one of the fubjects of his meditations, and prefented the plan of a reform in the education of Geneva: the tendency of which was, to make young people early acquainted with the natural fciences and mathematics. He even wifhed that their phyfical education fhould not be neglected, and with that view propofed gymnaftic exercifes. This plan, which excited much attention in a city where every one is convinced of the importance of education, found admirers and partifans; but the poverty of its pecuniary refources was an obftacle to every important innovation. It was befides feared that, by altering eftablifhed forms, they might lofe the fubftance, and that things might be changed for the worfe. The Genevefe were attached to their old fyftem of education; and they had reafon to be fo, becaufe it had not only proved the means of diffufing knowledge generally amongft them, but had called forth the talents of feveral eminent mathematicians (A) and philofophers (B).

But De Sauffure's attention was not confined to public education alone. He fuperintended himfelf the education of his two fons and a daughter, who have fhewn themfelves worthy of fuch an inftructor. His daughter to the charms of her fex unites an extenfive knowledge of the natural fciences; and his eldeft fon has already made himfelf known by his phyfical and chemical labours.

The fecond volume of his Travels was publifhed in 1786. It contains a defcription of the Alps around Mont Blanc, which the author confiders as a mineralogift, a geologift, and a philofopher. He gives alfo fome interefting experiments on electricity, and a defcription of his electrometer, one of the moft perfect that we have. We are indebted to him alfo for feveral inftruments of meafurement, fuch as his *cyanometer*, deftined to meafure the degree of the bluenefs of the heavens, which varies according to the elevation of the obferver; his *diaphanometer* (fee PHOTOMETER in this *Supplement*), and his *anemometer*, which, by means of a kind of balance, meafures the force of the wind.

Some years after the publication of the fecond volume of his Travels, De Sauffure was admitted as a foreign affociate of the Academy of Sciences of Paris; and Geneva could then boaft of having two of its citizens in that clafs, which confifted only of feven members. De Sauffure not only did honour to his country; he loved and ferved it. He was the founder of the Society of Arts, to which Geneva is indebted for the high ftate of profperity it has attained within the laft thirty years. He prefided over that fociety till the laft moment of his life; and one of his fondeft wifhes was the prefervation of this ufeful eftablifhment.

In confequence of M. de Sauffure's fatiguing labours in the Council of Two Hundred, of which he was a member, and afterwards in the National Affembly, his health began to be deranged, and in 1794 he was almoft deprived of the total ufe of his limbs by a ftroke of the palfy. However painful his condition then might be, his mind ftill preferved its activity; and after that accident he revifed the two laft volumes of his Travels, which appeared in 1796. They contain an account of his excurfions to the mountains of Piedmont and Switzerland, and in particular of his journey to the fummit of Mont Blanc. Thefe volumes, inftead of exhibiting any marks of his malady, prefent an enormous mafs of new facts and obfervations of the utmoft importance to phyfics.

He rendered alfo an important fervice to that fcience by publifhing the *Agenda*, which terminate his fourth volume, and in which that great man, furviving himfelf, conducts the young naturalift through the middle of mountains, and teaches him the method of obferving them with advantage. Thefe *Agenda* are a proof of his genius, and of the ftrength of mind which he retained amidft his fufferings. It was alfo during his illnefs that he directed the experiments made on the height of the bed of the Arve, and that he publifhed Obfervations on the Fufibility of Stones by the Blow-pipe, which were inferted in the *Journal de Phyfique*.

Having gone for the fake of his health to the baths of Plombiers, he ftill obferved the mountains at a diftance, and caufed to be brought to him fpecimens of the ftrata which he perceived in the fteepeft rocks. He had announced that he would conclude his travels with fome ideas on the primitive ftate of the earth; but the more he acquired new facts, and the more he meditated on the fubject, the more uncertain did his opinions become in regard to thofe grand revolutions which preceded the prefent epoch. In general he was a Neptunian; that is to fay, afcribed all the revolutions of our globe to water. He admitted the poffibility of the mountains having been thrown up by elaftic fluids difengaged from the cavities of the earth.

Though the ftate of his health began gradually to become worfe, he ftill entertained hopes of recovery; and the French government having appointed him profeffor of philofophy at the Special School of Paris, he did not defpair of being one day able to fill that office: but his ftrength was exhaufted, a general languor fucceeded the vigour he had always enjoyed, his flow and embarraffed pronunciation no longer correfponded with the vivacity of his mind, and formed a melancholy contraft with the pleafantnefs by which he had been formerly diftinguifhed. It was a painful fpectacle to fee this great man reduced thus to imbecility at an age when meditation is beneficial, and when he might have enjoyed the fruits of his reputation and labours.

In vain did he try, for the re-eftablifhment of his health, all the remedies which medicine, enlightened by the

(A) Abauzit, Cramer, Lhuilier, J. Trembley, &c.

(B) Jalabert, A. Trembley, Bonnet, Lefage, Deluc, Senebier, Prévoft, Pictet, and De Sauffure himfelf.

the phyfical fciences, could afford—all affiftance was ufelefs. The vital power quitted him with flow and painful fteps. Towards the beginning of autumn 1798 his decay became more vifible, his mind loft all its activity, and on the 22d of March 1799 he terminated his brilliant career, at the age of 59, lamented by a family to whom he was dear—by a country to which he had done honour—and by Europe, the knowledge of which he had extended.

SCALE, in architecture and geography, a line divided into equal parts, placed at the bottom of a map or draught, to ferve as a common meafure to all the parts of the building, or all the diftances and places of the map.

SCALES, in mathematics, fee SCALES *(Encycl.)*, and likewife *LOGARITHMIC Lines*, under which title are mentioned fome improvements by Mr Nicholfon on Gunter's fcale. Thefe improvements are valuable; and the reader will find a fuller account of them in the firft volume of the author's *Philofophical Journal*.

SCANTLING, a meafure, fize, or ftandard, by which the dimenfions, &c. of things are to be determined. The term is particularly applied to the dimenfions of any piece of timber, with regard to its breadth and thicknefs.

SCAPEMENT, in clock work, a general term for the manner of communicating the impulfe of the wheels to the pendulum. The ordinary fcapements confift of the fwing-wheel and pallets only; but modern improvements have added other levers or detents, chiefly for the purpofes of diminifhing friction, or for detaching the pendulum from the preffure of the wheels during part of the time of its vibration. See *WATCH Making*, in this *Suppl.*

SCARFING, a term in carpentry; by which is meant the joining of two beams of wood together to increafe the length: the beams in the joint are indented into one another, as in figures 19, 24, and 25, Plate X. *Supplement.*

SCARLET, a beautiful bright red colour given to cloth, either by a preparation of kermes (See that article in *Suppl.*), or more completely by the American cochineal. Profeffor Beckmann, in the fecond volume of his Hiftory of Inventions, feems to have eftablifhed the following conclufions:

1ft, Scarlet, or the kermes dye, was known in the Eaft in the earlieft ages, before Mofes, and was a difcovery of the Phœnicians in Paleftine, but certainly not of the fmall wandering Hebrew tribes. *2d*, *Tola* was the ancient Phœnician name ufed by the Hebrews, and even by the Syrians; for it is employed by the Syrian tranflator, Ifaiah, chap. 1. ver. 18. Among the Jews, after their captivity, the Aramæan word *zehori* was more common. *3d*, This dye was known alfo to the Egyptians in the time of Mofes; for the Ifraelites muft have carried it along with them from Egypt. *4th*, The Arabs received the name kermes, with the dye, from Armenia and Perfia, where it was indiginous, and had been long known; and that name banifhed the old name in the Eaft, as the name fcarlet has in the Weft. For the firft part of this affertion we muft believe the Arabs. *5th*, Kermes were perhaps not known in Arabia; at leaft they were not indiginous, as the Arabs appear to have had no name for them. *6th*, Kermes fignifies always *red dye*; and when pronounced fhort, it becomes *deep red*.

Concerning the origin of the name fcarlet, which was in ufe fo early as the 11th century, our author has many conjectures, which we need not tranfcribe, as he feems not quite fatisfied with any of them himfelf. The following reflections upon the comparative excellence of the ancient and modern fcarlet, together with the progrefs of the art of dyeing that colour, are worthy of notice:

"Of the preparation and goodnefs of the ancient fcarlet we certainly know nothing; but as we find in many old pieces of tapeftry of the 11th century, and perhaps earlier, a red which has continued remarkably beautiful even to the prefent time, it cannot at any rate be denied, that our anceftors extolled their fcarlet not without reafon. We can, however, venture to affert, that the fcarlet prepared at prefent is far fuperior, owing principally to the effects of a folution of tin.—This invention may be reckoned amongft the moft important improvements of the art of dyeing, and deferves a particular relation.

"The tincture of cochineal alone yields a purple colour, not very pleafant, which may be heightened to the moft beautiful fcarlet by a folution of tin in aqua-regia (nitro muriatic acid). This difcovery was made as follows: Cornelius Drebbel, who was born at Alkmaar, and died at London in 1634, having placed in his window an extract of cochineal, made with boiling water, for the purpofe of filling a thermometer, fome aqua-regia dropped into it from a phial, broken by accident, which ftood above it, and converted the purple dye into a moft beautiful dark red. After fome conjectures and experiments, he difcovered that the tin by which the window-frame was divided into fquares had been diffolved by the aqua-regia, and was the caufe of this change. He communicated his obfervation to Kuffelar, that excellent dyer at Leyden, who was afterwards his fon in-law. The latter brought the difcovery to perfection, and employed it fome years alone in his dye-houfe, which gave rife to the name of Kuffelar's colour. In the courfe of time the fecret became known to an inhabitant of Menin, called Gulich, and alfo to another perfon of the name of Van der Vecht, who taught it to the brothers Gobelins in France. Giles Gobelin, a dyer at Paris, in the time of Francis I. had found out an improvement of the then ufual fcarlet-dye; and as he had remarked that the water of the rivulet Bievre, in the fuburbs St Marceau, was excellent for his art, he erected on it a large dye-houfe; which, out of ridicule, was called *Folie Gobelins*, Gobelin's Folly. About this period, a Flemifh painter, whom fome name Peter Koek, and others Kloek, and who had travelled a long time in the Eaft, eftablifhed, and continued to his death in 1650, a manufactory for dyeing fcarlet cloth by an improved method. Through the means of Colbert, one of the Gobelins learned the procefs ufed for preparing the German fcarlet dye from one Gluck, whom fome confider as the above-mentioned Gulich, and others as Kloek; and the Parifian fcarlet dye foon rofe into fo great repute, that the populace imagined that Gobelin had acquired his art from the devil. It is well known that Louis XIV. by the advice of Colbert, purchafed Gobelin's building from his

his succeffors in the year 1667, and transformed it into a palace, to which he gave the name of *Hôtel royal des Gobelins*, and which he affigned for the ufe of firft rate artifts, particularly painters, jewellers, weavers of tapeftry, and others. After that time the rivulet was no longer called Bievre, but Gobelins. About the year 1643, a Fleming, named Kepler, eftablifhed the firft dye-houfe for fcarlet in England, at the village of Bow, not far from London; and on that account the colour was called, at firft, by the Englifh, the *Bow-dye*. In the year 1667, another Fleming, named Brewer, invited to England by King Charles II. with the promife of a large falary, brought this art there to great perfection."

SCHEME, a draught or reprefentation of any geometrical or aftronomical figure, or problem by lines fenfible to the eye; or of the celeftial bodies in their proper places for any moment; otherwife called a diagram.

SCIAGRAPHY, or Sciography, the profile or vertical fection of a building; ufed to fhew the infide of it.

Sciagraphy, in aftronomy, &c. is a term ufed by fome authors for the art of finding the hour of the day or night, by the fhadow of the fun, moon, ftars, &c.

SCIOPTIC, or *Scioptric Ball*, a fphere or globe of wood, with a circular hole or perforation, where a lens is placed. It is fo fitted, that, like the eye of an animal, it may be turned round every way, to be ufed in making experiments of the darkened room.

SCOLYMUS (fee that article *Encycl.*) is, by Pliny and Theophraftus, reckoned to belong to the genus of the thiftles. The former fays, that like moft others of the fame kind, the feeds were covered by a fort of wool *(pappus)*. It had a high ftem, furrounded with leaves which were prickly, but which ceafed to fting when the plant withered. It flowered the whole fummer through, and had often flowers and ripe feed at the fame time; which is the cafe alfo with our artichoke plants. The calyx of the *fcolymus* was not prickly; the root was thick, black, and fweet, and contained a milky juice. It was eaten both raw and cooked; and Theophraftus obferves, as fomething very remarkable, that when the plant was in flower, or, as others explain the words, when it had finifhed blowing, it was moft palatable. What renders this circumftance fingular is, that moft milky roots ufed for food lofe their milk, and become unfit to be eaten as foon as they have blown. This is the cafe with the goat's beard, which is eatable only the firft year.

Profeffor Beckmann has, with much labour and erudition, endeavoured to afcertain what is really the plant which was known to the ancients by the name of *fcolymus*. He feems to have proved fufficiently, that it was not the *cactus*, the *carduus*, or the *cinara*; but he has not been able to come to any other conclufion. "Were I appointed or condemned (fays he) to form a new Latin dictionary, I fhould explain the article *fcolymus* in the following manner: *Planta compofita, capitata. Caulis longus, obfitus foliis fpinofis. Radix carnofa, lactefcens, nigra, dulcis, edulis. Calix fquamis inermibus, difco carnofo, ante efflorefcentiam eduli. Semina pappofa. Turiones edules.* This defcription, fhort as it is, contains every thing that the ancients have faid in order to characterife that plant."

SCONCES, fmall forts, built for the defence of fome pafs, river, or other place. Some fconces are made regular, of four, five, or fix baftions; others are of fmaller dimenfions, fit for paffes or rivers; and others for the field.

SCOTALES, were meetings held formerly in England for the purpofe of drinking ale, of which the expence was defrayed by joint contribution. Thus the tenants of South Malling in Suffex, which belonged to the Archbifhop of Canterbury, were, at the keeping of a court, to entertain the Lord or his bailiff with a drinking, or an *ale;* and the ftated quotas towards the charge were, that a man fhould pay three-pence halfpenny for himfelf and his wife, and a widow and a cottager three half pence. In the manor of Ferring, in the fame county, and under the fame jurifdiction, it was the cuftom for the tenants named to make a *fcotale* of fixteen pence halfpenny, and to allow out of each fixpence three halfpence for the bailiff.

Common fcotales in taverns, at which the clergy were not to be prefent, are noticed in feveral ecclefiaftical canons. They were not to be publifhed in the church by the clergy or the laity; and a meeting of more than ten perfons of the fame parifh or vicinage was a fcotale that was generally prohibited. There were alfo common drinkings, which were denominated *leet-ale*, *bride-ale*, *clerk-ale*, and *church-ale*. To a *leet-ale* probably all the refidents in a manorial diftrict were contributors; and the expence of a *bride-ale* was defrayed by the relations and friends of a happy pair, who were not in circumftances to bear the charges of a wedding dinner. This cuftom prevails occafionally in fome diftricts of Scotland even at this day, under the denomination of a *penny bride-ale*, and was very common fifty or fixty years ago. The *clerk's*-ale was in the Eafter holidays, and was the method taken to enable clerks of parifhes to collect more readily their dues.

Mr Warton, in his Hiftory of Englifh Poetry, has inferted the following extract from an old indenture, which fhews clearly the defign of a *church*-ale. "The parifhioners of Elveftone and Okebrook, in Derbyfhire, agree jointly to brew four ales, and every ale of one quarter of malt, betwixt this and the feaft of St John the Baptift next coming; and that every inhabitant of the faid town of Okebrook fhall be at the feveral ales. And every hufband and his wife fhall pay two pence, every cottager one-penny; and all the inhabitants of Elvefton fhall have and receive all the profits and advantages coming of the faid ales, to *the ufe and behoof of the faid church of Elvefton.*"

The *give-ales* were the legacies of individuals; and from that circumftance entirely gratuitous. They feem to have been very numerous, and were generally left to the poor; though, from the largenefs of the quantity of ale enjoined to be brewed, it muft have been fometimes intended that others were to partake of them. Thefe bequefts were likewife, not unfrequently, made to the light or altar of a faint, with directions for finging maffes at the obit, trenthal, or anniverfary of the teftator. Hence, though fcotales were generally kept in houfes of public refort, the give-ales were fometimes difpenfed in the church, and often in the churchyard; by which means "Godde's houfe (as Sumner fays in his Treatife on Gavelkind) was made a tavern of gluttons." Such certainly would be Chalk church, if in it was

was kept the give-ale of William May of that parifh; for he ordered his wife to "make in bread fix bufhels of wheat, and in drink ten bufhels of mault, and in cheefe twenty-pence, to give to poor people for the health of his foul; and he ordered that, after the deceafe of his wife, his executors and feoffees fhould continue the cuftom for evermore."

SCOWRING OF STUFFS, is an art much more generally practifed than underftood. It fuppofes, fays Chaptal, 1ft, a knowledge of the different fubftances capable of ftaining any kind of cloth; 2d, of the fubftances to which recourfe muft be had, in order to make thofe depofited on the ftuff to difappear; 3d, a knowledge of the effects produced on colours by thofe re-agents, which it may be neceffary to employ to deftroy ftains; 4th, a knowledge of the manner in which the cloth is effected by thofe re agents; 5th, of the art of reftoring a colour changed or faded. Of thofe bodies which occafion fpots on different kinds of cloth, fome are eafily diftinguifhed by their appearance, fuch as greafy fubftances; but others have more complex effects, fuch as acids, alkalies, perfpired matter, fruits, urine, &c. Acids redden black, fawn, violet, and puce-colour, and every fhade communicated with orchilla-weed, iron, aftringents, and every blue except indigo and pruffian blue. They render the yellows paler, except that of arnatto, which they change into orange.

Alkalies change to violet the reds produced by Brazil-wood, logwood, and cochineal. They render the greens on woollen cloth yellowifh, make yellow brownifh, and change the yellow produced by arnatto to aurora. Perfpired matter produces the fame effects as alkalies.

When the fpots are produced by fimple bodies on ftuffs, it is eafy to remove them by the means already known. Greafy fubftances are removed by alkalies, foaps, the yolk of eggs, fat earths; oxides of iron, by the nitric and oxalic acids; acids by alkalies, and reciprocally. Stains of fruit on white ftuffs may be removed by the fulphureous acid, and ftill better by the oxigenated muriatic acid. But when the fpots are of a complex kind, it will be neceffary to employ feveral means in fucceffion. Thus, to deftroy the ftain of coom from carriage-wheels, after the greafe has been diffolved, the oxide of iron may be removed by the oxalic acid.

As colours are often changed by re-agents, it will be neceffary, in order to reftore them, that the fcowrer fhould poffefs a thorough knowledge of the art of dyeing, and how to modify the means according to circumftances. This becomes the more difficult, when it is neceffary to reproduce a colour fimilar to that of the reft of the ftuff, to apply that colour only in one place, and often to reftore the mordant by which it was fixed, and which has been deftroyed, or even the firft tint which gave the colour its intenfity. It may be readily conceived that the means to be employed muft depend on the nature of the colour and the ingredients by which it was produced; for it is known that the fame colour may be obtained from very different bodies. Thus, after an alkali has been employed to deftroy an acid fpot on browns, violets, blues, poppies, &c. the yellow fpot which remains may be made to difappear by a folution of tin; a folution of fulphat of iron reftores the colour to brown ftuffs which have been galled; acids reftore to their former fplendour yellows which have been rendered dufky or brown by alkalies; blacks produced by logwood become red by acids; alkalies change thefe red fpots to yellow, and a little of the aftringent principle makes them again become black. A folution of one part of indigo in four parts of fulphuric acid, diluted with a fufficient quantity of water, may be employed with fuccefs to revive the blue colour of cotton or wool which has been changed. Scarlet may be revived by means of cochineal and a folution of the muriat of tin, &c.

The choice of re-agents is not a matter of indifference. Vegetable acids are preferable; the fulphureous acid, however, may be employed for ftains occafioned by fruit; it does not change the blue of filk nor colours produced by aftringents; it does not degrade the yellow of cotton. Ammonia fucceeds better than fixed alkalies in removing fpots produced by acids. It is employed in vapour; its action is fpeedy, and feldom alters the colour.

The means of removing greafy fpots are well known. This effect is produced by alkalies, fullers earth, volatile oils diffolved in alcohol, a heat proper for volatilizing greafe, &c. Spots occafioned by ink, ruft, or iron-mould of any kind, and all thofe produced by the yellow oxide of iron, are removed by the oxalic acid: the colour may be reftored by alkalies, or a folution of the muriat of tin. Thefe fpots may be removed alfo by the oxygenated muriatic acid, when they are on white ftuffs or paper.

The action of alkalies, and that of perfpired matter, are the fame: their fpots may be effaced by acids, or even by a weak folution of the muriat of tin. When thefe fpots arife from feveral unknown caufes, in order to deftroy them, recourfe muft be had to polychreft compofitions. The following may be confidered as one of the moft efficacious: Diffolve white foap in alcohol, and mix this folution with the yolks of from four to fix eggs; add gradually effence of turpentine; and incorporate with the whole fome fullers earth, in fuch a manner as to form balls of a fuitable confiftence. Moiften the fpot; and having rubbed it with thefe balls, the fpot will be removed by wafhing the ftuff. All fpots, except iron-mould and ink, may be removed in this manner.

Wafhing deftroys the luftre, and leaves a tarnifhed place difagreeable to the eye; but the luftre may be reftored by drawing over the wafhed place, and in the direction of the pile, a brufh moiftened in water, impregnated with a little gum. You may then apply a fheet of paper, or a piece of cloth, and a confiderable weight, under which the cloth muft be left to dry.

SCYLLA. Under this title we gave, in the *Encyclopædia*, an account of Scylla and Charybdis, which, though taken from a work which we thought good authority, appears to be far from correct. Thefe places, fo famous in the poems of Homer and Virgil, were examined with minute attention by that accurate obferver of nature the Abbé Spallanzani; who thus defcribes Scylla.

"It is a lofty rock, diftant twelve miles from Meffina, which rifes almoft perpendicularly from the fea on the fhore of Calabria, and beyond which is the fmall city of the fame name. Though there was fcarcely any wind, I began to hear, two miles before I came to the rock,

rock, a murmur and noiſe like a confuſed barking of dogs, and on a nearer approach readily diſcovered the cauſe. This rock, in its lower parts, contains a number of caverns, one of the largeſt of which is called by the people there *Dragara*. The waves, when in the leaſt agitated, ruſhing into theſe caverns, break, daſh, throw up frothy bubbles, and thus occaſion theſe various and multiplied ſounds. I then perceived with how much truth and reſemblance of nature Homer and Virgil, in their perſonifications of Scylla, had pourtrayed this ſcene, by deſcribing the monſter they drew as lurking in the darkneſs of a vaſt cavern, ſurrounded by ravenous barking maſtiffs, together with wolves, to increaſe the horror.

"Such is the ſituation and appearance of Scylla; let us now conſider the danger it occaſions to mariners. Though the tide is almoſt imperceptible in the open parts of the Mediterranean, it is very ſtrong in the ſtrait of Meſſina, in conſequence of the narrowneſs of the channel, and is regulated, as in other places, by the periodical elevations and depreſſion of the water. Where the flow or current is accompanied by a wind blowing the ſame way, veſſels have nothing to fear, ſince they either do not enter the ſtrait, both the wind and the ſtream oppoſing them, but caſt anchor at the entrance; or, if both are favourable, enter on full ſail, and paſs through with ſuch rapidity that they ſeem to fly over the water. But when the current runs from ſouth to north, and the north wind blows hard at the ſame time, the ſhip which expected eaſily to paſs the ſtrait with the wind in its ſtern, on its entering the channel is reſiſted by the oppoſite current, and, impelled by two forces in contrary directions, is at length daſhed on the rock of Scylla, or driven on the neighbouring ſands; unleſs the pilot ſhall apply for the ſuccour neceſſary for his preſervation. For, to give aſſiſtance in caſe of ſuch accidents, 24 of the ſtrongeſt, boldeſt, and moſt experienced ſailors, well acquainted with the place, are ſtationed night and day along the ſhore of Meſſina; who, at the report of guns fired as ſignals of diſtreſs from any veſſel, haſten to its aſſiſtance, and tow it with one of their light boats. The current, where it is ſtrongeſt, does not extend over the whole ſtrait, but winds thro' it in intricate meanders, with the courſe of which theſe men are perfectly acquainted, and are thus able to guide the ſhip in ſuch a manner as to avoid it. Should the pilot, however, confiding in his own ſkill, contemn or neglect this aſſiſtance, however great his ability or experience, he would run the moſt imminent riſk of being ſhipwrecked. In this agitation and conflict of the waters, forced one way by the current, and driven in a contrary direction by the wind, it is uſeleſs to throw the line to diſcover the depth of the bottom, the violence of the current frequently carrying the lead almoſt on the ſurface of the water. The ſtrongeſt cables, though ſome feet in circumference, break like ſmall cords. Should two or three anchors be thrown out, the bottom is ſo rocky that they either take no hold; or, if they ſhould, are ſoon looſened by the violence of the waves. Every expedient afforded by the art of navigation, though it might ſucceed in ſaving a ſhip in other parts of the Mediterranean, or even the tremendous ocean, is uſeleſs here. The only means of avoiding being daſhed againſt the rocks, or driven upon the ſands in the midſt of this furious conteſt of the winds and waves, is to have recourſe to the ſkill and courage of theſe Meſſineſe ſeamen."

Charybdis is ſituated within the ſtrait, in that part of the ſea which lies between a projection of land named *Punta Secca*, and another projection on which ſtands the tower called *Lanterno*, or the light-houſe, a light being placed at its top to guide veſſels which may enter the harbour by night. Every writer, who has hitherto deſcribed Charybdis, has ſuppoſed it to be a whirlpool; but this is a miſtake, as Spallanzani has completely proved, by aſcertaining what it really is.

"Charybdis is diſtant from the ſhore of Meſſina about 750 feet, and is called by the people of the country *Calofaro*, not from the agitation of the waves, as ſome have ſuppoſed, but from καλος and φαρος; that is, *the beautiful tower*, from the light-houſe erected near it for the guidance of veſſels. The phenomenon of the Calofaro is obſervable when the current is deſcending; for when the current ſets in from the north, the pilots call it the *deſcending rema*, or current; and when it runs from the ſouth, the *aſcending rema*. The current aſcends or deſcends at the riſing or ſetting of the moon, and continues for ſix hours. In the interval between each aſcent or deſcent, there is a calm which laſts at leaſt a quarter of an hour, but not longer than an hour. Afterwards, at the riſing or ſetting of the moon, the current enters from the north, making various angles of incidence with the ſhore, and at length reaches the Calofaro. This delay ſometimes continues two hours; ſometimes it immediately falls into the Calofaro; and then experience has taught that it is a certain token of bad weather."

When our author obſerved Charybdis from the ſhore, it appeared like a group of tumultous waters; which group, as he approached, became more extenſive and more agitated. He was carried to the edge, where he ſtopped ſome time to make the requiſite obſervations; and was then convinced, beyond the ſhadow of a doubt, that what he ſaw was by no means a vortex or whirlpool.

Hydrologiſts teach us, that by a whirlpool in a running water we are to underſtand that circular courſe which it takes in certain circumſtances; and that this courſe or revolution generates in the middle of a hollow inverted cone, of a greater or leſs depth, the internal ſides of which have a ſpiral motion. But Spallanzani perceived nothing of this kind in the Calofaro. Its revolving motion was circumſcribed to a circle of at moſt 100 feet in diameter; within which limits there was no incurvation of any kind, nor vertiginous motion, but an inceſſant undulation of agitated waters, which roſe, fell, beat, and daſhed on each other. Yet theſe irregular motions were ſo far placid, that nothing was to be feared in paſſing over the ſpot, which he did; though their little bark rocked very much from the continual agitation, ſo that they were obliged conſtantly to make uſe of their oars to prevent its being driven out of the Calofaro. Our author threw ſubſtances of different kinds into the ſtream. Such as were ſpecifically heavier than the water ſunk, and appeared no more; thoſe which were lighter remained on the ſurface, but were ſoon driven out of the revolving circle by the agitation of the water.

Though from theſe obſervations he was convinced that there was no gulph under the Calofaro, as otherwiſe

Scylla, Sea fickness.

wife there would have been a whirlpool, which would have carried down into it the floating fubftances ; he determined to found the bottom with the plummet, and found its greateft depth did not exceed 500 feet. He was likewife informed, to his no fmall furprife, that beyond the Calofaro, towards the middle of the ftrait, the depth was double.

When the current and the wind are contrary to each other, and both in their greateft violence, efpecially when the fcilocco, or fouth wind, blows, the fwelling and dafhing of the waves within the Calofaro is much ftronger, more impetuous, and more extenfive. It then contains three or four fmall whirlpools, or even more, according to the greatnefs of its extent and violence. If at this time fmall veffels are driven into the Calofaro by the current or the wind, they are feen to whirl round, rock, and plunge, but are never drawn down into the vortex. They only fink when filled with water, by the waves beating over them. When veffels of a larger fize are forced into it, whatever wind they have they cannot extricate themfelves; their fails are ufelefs; and after having been for fome time toffed about by the waves, if they are not affifted by the pilots of the country, who know how to bring them out of the courfe of the current, they are furioufly driven upon the neighbouring fhore of the Lanterna, where they are wrecked, and the greater part of their crews perifh in the waves.

From thefe facts, the claffical reader will perceive that the ancient defcriptions of Charybdis are by no means fo accurate as thofe of Scylla. The faying, however, which became proverbial among the ancients, viz. that "he who endeavours to avoid Charybdis, dafhes upon Scylla," is, in a great meafure, true. If a fhip be extricated from the fury of Charybdis, and carried by a ftrong foutherly wind along the ftrait towards the northern entrance, it will indeed pafs out fafely ; but fhould it meet with a wind in a nearly oppofite direction, it would become the fport of both thefe winds, and, unable to advance or recede, be driven in a middle courfe between their two directions, that is to fay, full upon the rock of Scylla, if it be not immediately affifted by the pilots. It is likewife obferved, that in thefe hurricanes a land wind frequently rifes, which defcends from a narrow pafs in Calabria, and increafes the force with which the fhip is impelled towards the rock.

SEA-SICKNESS is a diforder which has been but little treated of, notwithftanding the frequency of its occurrence, and the irkfomenefs and diftrefs to which the patient is fubjected during its continuance. It has been found to be very beneficial in feveral difeafes, among which the principal are afthmatic and pulmonary complaints ; and there are very few inftances of its being attended with fatal confequences. The fea-ficknefs feems to be a fpafmodic affection of the ftomach, produced by the alternate preffure and recefs of the contents of that vifcus againft its lower internal furface, according as the rife and fall of the fhip oppofes or recedes from the action of gravity.

The feas in which this diforder attacks the paffenger with the greateft violence, are thofe where the waves have long uninterrupted freedom of action ; of courfe, bay, gulphs, and channels, may be navigated with lefs inconvenience, as the waves, meeting with more frequent refiftance, and the repercuffion being confiderably ftronger, the veffel does not experience that gentle uniform vacillation which fickens the ftomach, and renders the head giddy. By the fame argument, a perfon feels lefs inconvenience from the diforder on the wide ocean in a fmall veffel, on which the flighteft motion of the waves makes a ftrong impreffion. He is likewife lefs expofed to it in a very large veffel, as in a fhip of the line, or a large merchantman deeply laden ; as the waves, in this cafe, fcarcely affect the veffel. It is in fhips of the middling fize, and which carry but a light cargo, that the paffenger fuffers moft from the fea ficknefs. It has been obferved, that this diforder affects people in years lefs than young perfons ; thofe of a dark lefs than thofe of a fair complection, and that it feldom attacks infants. The duration is not limited to any fixed period of time; with fome it lafts only a few days, with others weeks, months, and even during the whole courfe of the voyage. The fooner it takes place after embarkation, the greater probability is there of its continuance. It does not always ceafe immediately on landing, but has been known, in fome cafes, to continue for a confiderable time. Even the oldeft and moft fkilful feamen have experienced a relapfe, efpecially if they have quitted the fea-fervice for a long term of years.

There have been many modes recommended for mitigating, if not entirely preventing, this diforder; among which the following feem the moft efficacious :

1. Not to go on board immediately after eating ; and, when on board, not to eat in any great quantity at any one meal.

2. To take ftrong exercife, with as little intermiffion as conveniently can be done ; for inftance, to affift at the pumps, or any other active employment, as indolent and flothful paffengers always fuffer moft from the diforder.

3. To keep much upon deck, even in ftormy and rainy weather, as the fea breeze is lefs liable to affect the ftomach than the ftagnated air of the cabin, which is frequently rendered infectious for want of fufficient circulation.

4. Not to watch the motion of the waves, efpecially when ftrongly agitated with tempeft.

5. To avoid carefully all employments which harafs the mind, as reading, ftudy, meditation, and gaming : and, on the other hand, to feek every opportunity of mirth and mental relaxation.

6. To drink occafionally carbonic acids, as the froth of ftrong fermented beer, or wine mixed with Seltzer water, and fermented with pounded fugar, or a glafs of Champaign.

7. It will be found of great fervice to take the acid of fulphur dulcified, dropped upon lump fugar, or in peppermint water ; or ten drops of fulphureous ether.

With regard to eating, it is advifable to be very fparing, at leaft not to eat much at one meal. The proper diet is bread and frefh meat, which fhould be eaten cold with pepper. All fweet favoured food fhould be carfully avoided ; and the paffenger fhould refrain from fat, but efpecially from all meat that is in the leaft degree tainted. Even the odour of flowers is very pernicious ; for which reafon it is not expedient to examine marine productions, as thefe generally have a naufeating fmell. The fumes of vinegar may be inhaled with great benefit. The drink fhould confift of

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tart wines, lemonade, or Seltzer water, but never of common water. The paſſenger would do well to drink little and often. As experience has proved, than an accidental diarrhœa has frequently relieved the patient from the ſea-ſickneſs, it will be prudent to follow the clue of nature, and take a gentle laxative, or, if circumſtances will permit, a clyſter of ſalt-water and Venice ſoap, which is the more neceſſary, as ſea-faring people are liable to obſtructions. It will further be found uſeful to apply to the pit of the ſtomach a tonic anodyne antiſpaſmodic emplaſtrum, ſpread upon leather, and covered with linen.

Where the above preventives have not been employed, or have not ſucceeded in ſecuring the paſſenger from the ſea-ſickneſs, he may, however, experience conſiderable relief from the following remedies:

If ſymptoms of vomiting appear, they may frequently be remedied by the patient proſtrating himſelf in a horizontal poſition, upon the back or belly, and lying perfectly ſtill. We would recommend likewiſe a gentle compreſſion of the abdomen. But if the fits of vomiting are too violent to be repreſſed, in that caſe, it is beſt to promote them by a ſtrong doſe of ſalt water; an expedient, however, which muſt not be too often repeated, as it tends ſtill more to weaken the ſtomach. When the emetic takes effect, let the patient bend his body, advancing his knees towards his breaſt, and ſupport his head againſt a firm and ſolid reſting-place. He muſt be particularly careful to untie his garters and cravat, as this precaution will ſecure him from the riſk of a rupture, and from the ill effects of the blood ruſhing violently towards the head and breaſt.

After the vomiting has ſubſided, its return may be guarded againſt by preſerving a ſtate of repoſe, and even keeping the eyes ſhut for a conſiderable time. Let the patient chooſe a cool, ventilated place, remembering to keep himſelf warm and well clothed, as perſpiration is highly ſalutary. But he muſt not indulge in too long ſleep during the day-time, as this induces torpidneſs. In the morning he ſhould conſtantly take a gargle of ſugar diſſolved in vinegar. Let him eat often, but ſparingly; and if he can content himſelf with a diſh of chocolate, coffee, or ſtrong tea, he will reap ſtill greater benefit. He ſhould never drink water in its pure elementary ſtate, but mix it with brandy, vinegar, or wine. In the morning, inſtead of brandy, he may take a glaſs of wine, with an infuſion of orange peel, gentian root, or peruvian bark (*quinquina*). A glaſs of punch taken occaſionally will prove of very eſſential ſervice, as it promotes perſpiration.

Perſons in the habit of ſmoking, will find a pleaſant and ſalutary companion in the pipe; but thoſe who are not accuſtomed to it will be ſufferers by taking to the practice.

In concluſion, it is proper to add, that warm clothing, flannel ſhirts, trowſers, caps, &c. are efficacious remedies againſt exceſſive expectoration, and all other ſymptoms of this terrible diſorder.

SECTOR OF A SPHERE, is the ſolid generated by the revolution of the ſector of a circle about one of its radii; the other radius deſcribing the ſurface of a cone, and the circular arc a circular portion of the ſurface of the ſphere of the ſame radius. So that the ſpherical ſector conſiſts of a right cone, and of a ſegment of the ſphere having the ſame common baſe with the cone. And hence the ſolid content of it will be found by multiplying the baſe or ſpherical ſurface by the radius of the ſphere, and taking a third part of the product.

SECTOR *of an ellipſe*, or *of an hyperbola*, &c. is a part reſembling the circular ſector, being contained by three lines, two of which are radii, or lines drawn from the centre of the figure to the curve, and the intercepted arc or part of that curve.

SEEDS, PRESERVATION OF, in a ſtate fit for vegetation, is a matter of great and general importance, becauſe, if it can be accompliſhed, it will enable us to rear many uſeful plants in one country which are there unknown, being indigenous only in others at a great diſtance from it. There is a letter on this ſubject in the 16th volume of the *Tranſaction of the Society of Arts*, &c. from which we ſhall extract what is fit for our purpoſe.

"Many years ago (ſays the author), having obſerved ſome ſeeds which had got accidentally amongſt raiſins, and that they were ſuch as are generally attended with difficulty to raiſe in England after coming in the uſual way from abroad, I ſowed them in pots, within a framing; and as all of them grew, I commiſſioned my ſons, who were then abroad, to pack up all ſorts of ſeeds they could procure in abſorbent paper, and ſend ſome of them ſurrounded by raiſins, and others by brown moiſt ſugar; concluding that the former ſeeds had been preſerved by a peculiarly favourable ſtate of moiſture thus afforded them. It occurred, likewiſe, that as many of our common ſeeds, ſuch as clover, charlock, &c. would lie dormant for ages within the earth, well preſerved for vegetation whenever they might happen to be thrown to the ſurface, and expoſed to the atmoſphere, ſo theſe foreign ſeeds might be equally preſerved, for many months at leaſt, by the kindly covering and genial moiſture that either raiſins or ſugar afforded them: and this conjecture was really fulfilled, as not one in twenty of them failed to vegetate, when thoſe of the ſame kinds, that I ordered to be ſent lapped in common parcels, and forwarded with them, would not grow at all. I obſerved, upon examining them all before they were committed to the earth, that there was a prevailing dryneſs in the latter, and that the former looked freſh and healthy, and were not in the leaſt infeſted by inſects, as was the caſe with the others. It has been tried repeatedly to convey ſeeds (of many plants difficult to raiſe) cloſed up in bottles, but without ſucceſs; ſome greater proportion of air, as well as a proper ſtate of moiſture, perhaps, being neceſſary. I ſhould alſo obſerve, that no difference was made in the package of the ſeeds, reſpecting their being kept in huſks, pods, &c. ſo as to give thoſe in raiſins or ſugar any advantage over the others, all being ſent equally guarded by their natural teguments."

SEGALIEN, the name given by Europeans to a large iſland, ſeparated by a narrow channel from the coaſt of Chineſe Tartary, and called by the natives *Tchoka*, and by the Chineſe *Oku-Jeſſu*. It lies between the 46th and 54th degrees of north latitude, but its breadth from eaſt to weſt is not known. Indeed hardly any thing about it was known till the year 1787, that M. La Perouſe penetrated almoſt to the bottom of the channel which ſeparates it from the continent, and which grew ſo very ſhallow as he advanced northward that, Segalien. that, in all probability, the island will soon become a peninsula. The French frigates came to anchor in different bays on the coast of Segalien; and the finest of these bays, to which the Commodore gave the name of *Baie d'Estaing*, is situated in 48° 59′ N. Lat. and 140° 32′ Lon. East from Paris.

La Perouse, and M. Rollin the surgeon of his ship, both describe the natives of this island as a worthy and intelligent people. Of the presents which were made to them, they seemed to set a value only on such as were useful. Iron and stuffs prevailed over every thing; they understood metals as well as their guests, and for ornament preferred silver to copper, and copper to iron. They make use of looms, which, though small, are very complete instruments; and by means of spindles they prepare thread of the hair of animals, of the bark of the willow, and the great nettle, from which they make their stuffs. They are of a moderate size, squat, and strong built, with the muscles of their bodies very exactly defined: their common height is five feet, and the greatest does not exceed five feet four inches; but men of this size are very uncommon among them. They have all a large head, and a broad and more rounded face than Europeans; their countenance is animated and agreeable, though, upon the whole, it is destitute of that regularity and grace which we esteem so essential to beauty: they have large cheeks, a short nose rounded at its extremity, with very broad nostrils: their eyes are lively, of a moderate size, for the most part black, though some have blue ones among them: their eyebrows are bushy, their mouth of the common size, their voice is strong, their lips are rather thick, and of a dull red: M. Rollin remarked, that in several the upper lip was tattoed, and tinged of a blue colour: these, as well as their eyes, are capable of every variety of expression: their teeth are white, even, and of the usual number; their chin is rounded and a little advancing: their ears are small; they bore and wear in them glass ornaments or silver rings.

The women are not so large as the men, and are of a more rounded and delicate figure, though there is but little difference between the features of their faces. Their upper lip is tattoed all over of a blue colour, and they wear their hair long and flowing: their dress hardly differs from that of the men; the colour of the skin in both sexes is tawny, and that of their nails, which they suffer to grow to a great length, is a shade darker than that of Europeans. These islanders are very hairy, and have long beards, which gives, especially to the old men, a grave and venerable air: these last appear to be held in much respect by the younger part of the inhabitants. The hair of their head is black, smooth, and moderately strong; in some it is of a chesnut colour: they all wear it round, about six inches long behind, and cut into a brush on the top of their head and over the temples.

Their clothing consists of a kind of surtout which wraps over before, where it is fastened by little buttons, strings, and a girdle placed above the haunches. This surtout is made of skin or quilted nankeen, a kind of stuff that they make of willow bark; it generally reaches to the calf of the leg, and sometimes even lower, which for the most part renders the use of drawers unnecessary: some of them wear seal skin boots, the feet of which, in form and workmanship, resembles the Chinese shoe; but the greater number of them go bare-footed and bare-headed: a few indeed wear a bandage of bear-skin round the head; but this is rather as an ornament than a defence against the weather.

Segalien. Like the lower classes of the Chinese, they all wear a girdle, to which they hang their knife as a defence against the bears, and several little pockets, into which they put their flint and steel, their pipe, and their box of tobacco; for they make a general practice of smoking.

Their huts are sufficient to defend them against the rain and other inclemencies of the air, but are very small in proportion to the number of the inhabitants which they contain. The roof is formed of two inclined planes, which are from ten to twelve feet high at their junction, and three or four on the sides: the breadth of the roof is about fifteen feet, and its length eighteen: these cabins are constructed of frame work, strongly put together, the sides being filled up with the bark of trees, and the top thatched with dry grass in the same manner as our cottages are.

On the inside of these houses is a square of earth raised about six inches above the ground, and supported on the sides by strong planking; on this they make the fire: along the sides of the apartment are benches twelve or fifteen inches high, which they cover with mats, on which they sleep.

The utensils that they employ in cooking their food consist of an iron pot, shells, vessels made of wood and birch bark, of various shapes and workmanship; and, like the Chinese, they take up their food with little sticks: they have generally two meals in the day, one at noon, and the other in the evening.

The habitations in the south part of the island are much better built and furnished, having for the most part planked floors: our author saw in them some vessels of Japan porcelain, on which the owners appeared to set great value, probably because they are not to be procured but with great trouble and at considerable expence. They cultivate no kind of vegetable, living only on dried and smoked fish, and what little game they take by hunting.

Each family has its own canoe, and implements for fishing and hunting. Their arms are bows, javelins, and a kind of spontoon, which they use principally in bear-hunting. By the side of their houses are the magazines, in which they lay up the provision which they have prepared and collected during summer for their winter subsistence. It consists of dried fish, and a considerable quantity of garlic and wild celery, angelica, a bulbous root which they call *apè*, better known under the name of the yellow lily of Kamtschatka, and fish oil, which they preserve in the stomachs of bears, and other large animals. These magazines are made of planks, strongly and closely put together, raised above the ground on stakes about four feet high.

Dogs are the only domestic animals belonging to the natives of Tchoka; they are of a middling size, with shaggy hair, pricked ears, and a sharp long muzzle; their cry is loud and not savage.

These people, who are of a very mild and unsuspecting disposition, appear to have commercial intercourse with the Chinese by means of the Mantchou Tartars, with the Russians to the north of their island, and the Japanese to the south: but the articles of trade are of

 no

no great confequence, confifting only of a few furs and whale oil. This fifh is caught only on the fouthern coaft of the ifland. Their mode of extracting the oil is by no means economical; they drag the whale on fhore on a floping ground, and fuffering it to putrify, receive in a trench, at the foot of the flope, the oil, which feparates fpontaneoufly.

The ifland is well wooded, and mountainous towards the centre, but is flat and level along the coaft, the foil of which appears admirably adapted to agriculture: vegetation is extremely vigorous here: forefts of pine, willow, oak, and birch, cover nearly the whole furface. The fea abounds with fifh, as well as the rivers and brooks, which fwarm with falmon and trout of an excellent quality. The weather is, in general, foggy and mild. All the inhabitants have an air of health and ftrength, which they retain even to extreme old age; nor did our author obferve among them any inftance of defective organization, or the leaft trace of contagious or eruptive diforders.

SEGMENTS, LINE OF, are two particular lines, fo called on Gunter's fector. They lie between the lines of fines and fuperficies, and are numbered with 5, 6, 7, 8, 9, 10. They reprefent the diameter of a circle, fo divided into 100 parts, as that a right line drawn through thofe parts, and perpendicular to the diameter, fhall cut the circle into two fegments, the greater of which fhall have the fame proportion to the whole circle, as the parts cut off have to 100.

SEGO, the capital of the kingdom of Bambarra in Africa, is fituated on the banks of the Niger, in 14° 4′ N. Lat. and 2° 1′ W. Long. It confifts, properly fpeaking, of four diftinct towns; two on the northern bank of the Niger, called Sego Korro, and Sego Boo; and two on the fouthern bank, called Sego Soo Korro, and Sego See Korro. They are all furrounded with high mud-walls; the houfes are built of clay, of a fquare form, with flat roofs; fome of them have two ftories, and many of them are white-wafhed. Befides thefe buildings, Moorifh mofques are feen in every quarter; and the ftreets, though narrow, are broad enough for every ufeful purpofe in a country where wheel-carriages are entirely unknown. Mr Park informs us, that from the beft inquiries that he could make, he has reafon to believe that Sego contains altogether about thirty thoufand inhabitants. The King of Bambarra conftantly refides at Sego. See Korro. He employs a great many flaves in conveying people over the river; and the money they receive (though the fare is only ten kowrie fhells for each individual) furnifhes a confiderable revenue to the king in the courfe of a year. The canoes are of a fingular conftruction, each of them being formed of the trunks of two large trees, rendered concave, and joined together, not fide by fide, but endwife; the junction being exactly acrofs the middle of the canoe: they are therefore very long, and difproportionably narrow, and have neither decks nor mafts; they are, however, very roomy; for our author obferved in one of them four horfes, and feveral people, croffing over the river. The view of this extenfive city; the numerous canoes upon the river; the crowded population, and the cultivated ftate of the furrounding country, formed altogether a profpect of civilization and magnificence which he little expected to find in the bofom of Africa.

He met not, however, in Sego with that hofpitality which he had experienced in fome other African towns. The Moors, who abound in it, and whofe bigotry renders them the implacable enemies of every white man fufpected of being a Chriftian, contrived to perfuade the king that it was for no good purpofe he had come into the territories of Bambarra. He was therefore ordered to take up his refidence at a village a little diftant, without being admitted into the royal prefence. Even there, fo ftrong was the prejudice that had been excited againft him, no perfon would admit him into his houfe. About funfet, however, as he was preparing to pafs the night in the top of a tree, that he might not be in danger of being torn to pieces by wild beafts, a poor Negro woman conducted him to her hut, dreffed a fine fifh for his fupper, and furnifhed him with a mat to fleep on. She then called to the female part of her family, who had ftood gazing on him all the while with fixed aftonifhment, to refume their tafk of fpinning cotton; in which they continued to employ themfelves great part of the night. They lightened their labour by fongs; one of which was compofed extempore, for our author was himfelf the fubject of it. It was fung by one of the young women, the reft joining in a fort of chorus. The air was fweet and plaintive, and the words, literally tranflated, were thefe: "The winds roared, and the rains fell.—The poor white man, faint and weary, came and fat under our tree.—He has no mother to bring him milk; no wife to grind his corn.—*Chorus.* Let us pity the white man; no mother has he, &c. &c. "Trifling (fays Mr Park) as this recital may appear to the reader, to a perfon in my fituation the circumftance was affecting in the higheft degree."

Having remained three days in this village, he was difmiffed on the fourth, after receiving from the king 5000 kowries, to enable him to purchafe provifions in the courfe of his journey. Though this fum amounted only to one pound fterling, fo cheap are the neceffaries of life in Bambarra, that it was fufficient to purchafe provifions for himfelf, and corn for his horfe, for fifty days.

SELL, in building, is of two kinds, viz. *Ground Sell*, which denotes the loweft piece of timber in a wooden building, and that upon which the whole fuperftructure is raifed; and *Sell of a Window*, or *of a Door*, which is the bottom piece in the frame of them, upon which they reft.

SENN, a kind of itinerant cowkeeper in Switzerland, particularly in the canton of Appenzell. Thefe men do not grow fo much hay themfelves as they require for their cattle during the winter feafon, and fome of them have no grafs lands at all. To fupply this deficiency, they employ agents throughout the canton, who are to inform them where good hay may be obtained, which farmers made it in favourable weather, &c. and then the Senn, or the great cowkeeper, who is in want of fodder, makes his agreements for the winter with the wealthier farmers, to whom he fucceffively drives his cattle as foon as they return from grafs. Thus the itinerant Senn, with his cows, often vifits five different places during the winter feafon. He who fells the hay, furnifhes the Senn not only with ftabling for his beafts, but boards and lodges him as well as his whole family. In return, the Senn, befides paying the ftipulated price for the hay, allows to his hoft as much milk, whey, and *zieger* (a kind of lean cheefe) as may be be ufed in the houfe, and leaves him alfo the manure of his cows. In the middle of April, when Nature revives, the Senn again iffues forth with his herd to the meadows and fertile Alps, which he rents for the fummer. Thus the life of thefe men is a conftant migration, affording the moft pleafing variety, and bleffing them with health, content, and cheerfulnefs; but they had not been then curfed with French fraternity.

Fine cattle are the pride of the cowkeeper who inhabits the Alps:—but, not fatisfied with their natural beauty, he will likewife pleafe his vanity. He adorns his beft cows with large bells fufpended from broad thongs; and the expence in fuch bells is carried even to a luxurious excefs. Every Senn has an harmonious fet of at leaft two or three bells, chiming in with the famous *ranz des vaches* (A). The inhabitants of the Tyrol bring a number of fuch bells, of all fizes, to every fair kept in the canton of Appenzell. They are fixed to a broad ftrap, neatly pinked, cut out, and embroidered; which is faftened round the cow's neck by means of a large buckle. A bell of the largeft fize meafures upwards of a foot in diameter, is of an uniform width at top, fwells out in the middle, and tapers towards the end. It cofts from forty to fifty gilders; and the whole peal of bells, including the thongs, will fometimes be worth between 140 and 150 gilders, while the whole apparel of the Senn himfelf, when beft attired, does not amount to the price of twenty gilders. The fineft black cow is adorned with the largeft bell, and thofe next in appearance have two fmaller. Thefe ornaments, however, are not worn on every day, but only on folemn occafions, viz. when, in the fpring, they are driven up the Alps, or removed from one pafture to another; or when they defcend in the autumn, or travel in the winter to the different farms, where their owner has contracted for hay. On fuch days, the Senn, even in the depth of winter, appears dreffed in a fine white fhirt, of which the fleeves are rolled up above the elbow; neatly embroidered red braces keep up his yellow linen trowfers, which reach down to the fhoes; a fmall leather cap, or hat, covers his head; and a new milk bowl, of wood fkilfully carved, hangs acrofs the left fhoulder. Thus arrayed, the Senn precedes finging the *ranz des vaches*, and followed by three or four fine goats; next comes the handfomeft cow with the great bell; then the two other cows with fmaller bells; and thefe are fucceeded by the reft of the cattle walking one after another, and having in their rear the bull with a one-legged milking ftool hanging on his horns; the proceffion is clofed by a *traineau*, or fledge, on which are placed the implements for the dairy. It is furprifing to fee how proud and pleafed the cows ftalk forth when ornamented with their bells. Who would imagine that even thefe animals are fenfible of their rank, nay, touched with vanity and jealoufy! If the leading cow, who hitherto bore the largeft bell, be deprived of her honours, fhe very plainly manifefts her grief at the difgrace, by lowing inceffantly, abftaining from food, and growing lean. The happy rival, on whom the diftinguifhing badge of fuperiority has devolved, experiences her marked vengeance, and is butted, wounded, and perfecuted by her in the moft furious manner; until the former either recovers her bell, or is entirely removed from the herd. However fingular this phenomenon may appear, it is placed beyond all doubt by the concurring teftimony of centuries.

The cows, when difperfed on the Alps, are brought together by the voice of the Senn, who is then faid to *allure* them (*locken*). How well the cattle diftinguifh the note of their keeper appears from the circumftance of their haftening to him, though at a great diftance, whenever he begins to hum the *ranz des vaches*. He furnifhes that cow which is wont to ftray fartheft with a fmall bell, and knows by her arrival that all the reft are affembled.

SERRISHTEHDAR, in Bengal, keeper of records or accounts.

SEVEN STARS, a common denomination given to the clufter of ftars in the neck of the fign Taurus, the bull, properly called the *Pleiades*. They are fo called from their number Seven which appear to the naked eye, though fome eyes can difcover only fix of them; but by the help of telefcopes there appears to be a great multitude of them.

SESAWUL, in Bengal, an officer deputed occafionally to enforce the due payment of the revenue.

SHADOWS (COLOURED), a curious optical phenomenon, which was obferved, a confiderable number of years ago, by Profeffor Scherffer of Vienna, and more lately by Count Rumford. The Count made the difcovery when profecuting his experiments upon light; of which the reader will find fome account under the titles LAMP and PHOTOMETER in this *Suppl.* "Defirous (fays he) of comparing the intenfity of the light of a clear blue fky by day with that of a common wax-candle, I darkened my room, and letting the day light from the north, coming through a hole near the top of the window fhutter, fall at an angle of about 70° upon a fheet of very fine white paper, I placed a burning wax candle in fuch a pofition that its rays fell upon the fame paper, and, as near as I could guefs, in the line of reflection of the rays of day-light from without; when, interpofing a cylinder of wood, about half an inch in diameter, before the centre of the paper, and at the diftance of about two inches from its furface, I was much furprifed to find that the two fhadows projected by the cylinder upon the paper, inftead of being merely fhades without colour, as I expected; the one of them, that which, correfponding with the beam of day-light, was illuminated by the candle, was yellow; while the other, correfponding to the light of the candle, and confequently illuminated by the light of the heavens, was of the moft beautiful blue that it is poffible to imagine. This appearance, which was not only unexpected, but was really in itfelf in the higheft degree ftriking and beautiful,

(A) This famous paftoral fong is never fung by the cowherds with words to it: all the tones of it are fimple, and moftly formed within the throat. Hence the tune produces very little or no motion of the jawbones, and its founds do not refemble thofe which commonly iffue from the human throat, but rather feem to be the tones of fome wind inftrument: particularly as fcarcely any breathing is perceived, and as the cowherds fometimes fing for minutes together without fetching breath.

Shadows, Shagreen. beautiful, I found upon repeated trials, and after varying the experiment in every way I could think of, to be so perfectly permanent, that it is absolutely impossible to produce two shadows at the same time, from the same body, the one answering to a beam of day light, and the other to the light of a candle or lamp, without these shadows being coloured, the one yellow, and the other blue.

"If the candle be brought nearer to the paper, the blue shadow will become of a deeper hue, and the yellow shadow will gradually grow fainter; but if it be removed farther off, the yellow shadow will become of a deeper colour, and the blue shadow will become fainter; and the candle remaining stationary in the same place, the same varieties in the strength of the tints of the coloured shadows may be produced merely by opening the window-shutter a little more or less, and rendering the illumination of the paper, by the light from without, stronger or weaker. By either of these means, the coloured shadows may be made to pass through all the gradations of shade, from the deepest to the lightest, and *vice versa*; and it is not a little amusing to see shadows thus glowing with all the brilliancy of the purest and most intense prismatic colours, then passing suddenly through all the varieties of shade, preserving in all the most perfect purity of tint, growing stronger and fainter, and vanishing and returning, at command."

With respect to the causes of the colours of these shadows, there is no doubt (says the Count) but they arise from the different qualities of the light by which they are illuminated: but how they are produced, does not appear to him so evident. With the utmost deference to this amiable and very ingenious philosopher, we think all the phenomena of coloured shadows which he enumerates *, have been, or may be accounted for by Professor Scherffers theory; of which the reader will find, we hope, a perspicuous view under *Accidental* COLOURS in this *Supplement*.

* *Phil. Transf.* 1794, p. 107.

SHAGREEN, or CHAGRIN, in commerce, a kind of grained leather; of the process of preparing which, we gave the best account that we could then find in the *Encyclopædia*. That account, however, as we learn from Professor Pallas, is very defective. He says, indeed, that no accurate account of it has ever been published in Europe previous to his own; of which we shall now lay an abridgment before our readers.

"All kinds of horses or asses skin, which have been dressed in such a manner as to appear grained, are, by the Tartars, called *sauwer*, by the Persians *sogre*, and by the Turks *sagri*, from which the Europeans have made *shagreen* or *chagrin*. The Tartars who reside at Astracan, with a few of the Armenians of that city, are the only people in the Russian empire acquainted with the art of making shagreen. Those who follow this occupation not only gain considerable profit by the sale of their production to the Tartars of Cuban, Astracan, and Casan, who ornament with it their Turkey leather boots, slippers, and other articles made of leather, but they derive considerable advantage from the great sale of horses hides, which have undergone no other process than that of being scraped clean, and of which several thousands are annually exported, at the rate of from 75 to 85 roubles per hundred to Persia, where there is a scarcity of such hides, and from which the greater part of the shagreen manufactured in that country is prepared. The hind part only of the hide, however, which is cut out in the form of a crescent about a Russian ell and a half in length across the loins, and a short ell in breadth along the back, can properly be employed for shagreen. The remaining part, as is proved by experience, is improper for that purpose, and is therefore rejected.

Shagreen.

"The preparation of the skins, after being cut into the above form, is as follows:—They are deposited in a tub filled with pure water, and suffered to remain there for several days, till they are thoroughly soaked, and the hair has dropped off. They are then taken from the tub, one by one, extended on boards placed in an oblique direction against a wall, the corners of them, which reach beyond the edges of the board, being made fast, and the hair with the epidermis is then scraped off with a blunt iron scraper called *urak*. The skins thus cleaned are again put in pure water to soak. When all the skins have undergone this part of the process, they are taken from the water a second time, spread out one after the other as before, and the flesh side is scraped with the same kind of instrument. They are carefully cleaned also on the hair side, so that nothing remains but the pure fibrous tissue, which serves for making parchment, consisting of coats of white medullary fibres, and which has a resemblance to a swine's bladder softened in water.

"After this preparation, the workmen take a certain kind of frames called *pälzi*, made of a straight and a semicircular piece of wood, having nearly the same form as the skins. On these the skins are extended in as smooth and even a manner as possible by means of cords; and during the operation of extending them, they are several times besprinkled with water, that no part of them may be dry, and occasion an unequal tension. After they have been all extended on the frames, they are again moistened, and carried into the house, where the frames are deposited close to each other on the floor with the flesh side of the skin next the ground. The upper side is then thickly bestrewed with the black exceedingly smooth and hard seeds of a kind of goose foot (*chenopodium album*), which the Tartars call *alabuta*, and which grows in abundance, to about the height of a man, near the gardens and farms on the south side of the Volga; and that they may make a strong impression on the skins, a piece of felt is spread over them, and the seeds are trod down with the feet, by which means they are deeply imprinted into the soft skins. The frames, without shaking the seeds, are then carried out into the open air, and placed in a reclining position against a wall to dry, the side covered with the seeds being next the wall, in order that it may be sheltered from the sun. In this state the skins must be left several days to dry in the sun, until no appearance of moisture is observed in them, when they are fit to be taken from the frames. When the impressed seeds are beat off from the hair side, it appears full of indentations or inequalities, and has acquired that impression which is to produce the grain of the shagreen, after the skins have been subjected to the last smoothing or scraping, and have been dipped in a ley, which will be mentioned hereafter, before they receive the dye.

"The operation of smoothing is performed on an inclined bench or board, which is furnished with an iron hook, and is covered with thick felt of sheep's wool, on

Shagreen. on which the dry ſkin may gently reſt. The ſkin is ſuſpended in the middle of the bench or board to its iron hook, by means of one of the holes made in the edge of the ſkin for extending it in its frame as before mentioned; and a cord, having at its extremity a ſtone or a weight, is attached to each end of the ſkin, to keep it in its poſition while under the hands of the workman. It is then ſubjected to the operation of ſmoothing and ſcraping by means of two different inſtruments. The firſt uſed for this purpoſe, called by the Tartars *tokar*, is a piece of ſharp iron bent like a hook, with which the ſurface of the ſhagreen is pretty cloſely ſcraped to remove all the projecting inequalities. This operation, on account of the corneous hardneſs of the dry ſkin, is attended with ſome difficulty; and great caution is at the ſame time required that too much of the impreſſion of the *alabuta* ſeed be not deſtroyed, which might be the caſe if the iron were kept too ſharp. As the iron, however, is pretty blunt, which occaſions inequalities on the ſhagreen, this inconvenience muſt afterwards be remedied by means of a ſharp ſcraping iron or *urak*, by which the ſurface acquires a perfect uniformity, and only faint impreſſions of the *alabuta* ſeed then remain, and ſuch as the workman wiſhes. After all theſe operations, the ſhagreen is again put into water, partly to make it pliable, and partly to raiſe the grain. As the ſeeds occaſion indentations in the ſurface of the ſkin, the intermediate ſpaces, by the operations of ſmoothing and ſcraping, loſe ſome part of their projecting ſubſtance; but the points which have been depreſſed, and which have loſt none of their ſubſtance, now ſwell up above the ſcraped parts, and thus form the grain of the ſhagreen. To produce this effect, the ſkins are left to ſoak in water for 24 hours; after which they are immerſed ſeveral times in a ſtrong warm ley, obtained, by boiling, from a ſtrong alkaline earth named *ſchora*, which is found in great abundance in the neighbourhood of Aſtracan. When the ſkins have been taken from this ley, they are piled up, while warm, on each other, and ſuffered to remain in that ſtate ſeveral hours; by which means they ſwell, and become ſoft. They are then left 24 hours in a moderately ſtrong pickle of common ſalt, which renders them exceedingly white and beautiful, and fit for receiving any colour. The colour moſt uſual for theſe ſkins is a ſea-green; but old experienced workmen can dye them blue, red, or black, and even make white ſhagreen.

"For the green colour nothing is neceſſary but filings of copper and ſal ammoniac. Sal ammoniac is diſſolved in water till the water is completely ſaturated; and the ſhagreen ſkins, ſtill moiſt, after being taken from the pickle, are waſhed over with the ſolution on the ungrained fleſh ſide, and when well moiſtened a thick layer of copper filings is ſtrewed over them: the ſkins are then folded double, ſo that the ſide covered with the filings is innermoſt. Each ſkin is then rolled up in a piece of felt; the rolls are all ranged together in proper order, and they are preſſed down in an uniform manner by ſome heavy bodies placed over them, under which they remain 24 hours. During that period, the ſolution of ſal ammoniac diſſolves a quantity of the cupreous particles ſufficient to penetrate the ſkin, and to give it a ſea-green colour. If the firſt application be not ſufficient, the proceſs is repeated in the ſame manner; after which the ſkins are ſpread out and dried.

"For the blue dye, indigo is uſed. About two pounds of it, reduced to a fine powder, are put into a kettle; cold water is poured over it, and the mixture is ſtirred round till the colour begins to be diſſolved. Five pounds of pounded *alakar*, which is a kind of barilla or crude ſoda, prepared by the Armenians and Calmucs, is then diſſolved in it, with two pounds of lime and a pound of pure honey, and the whole is kept ſeveral days in the ſun, and during that time frequently ſtirred round. The ſkins intended to be dyed blue muſt be moiſtened only in the natrous ley *ſchora*, but not in the ſalt brine. When ſtill moiſt, they are folded up and ſhewed together at the edge, the fleſh ſide being innermoſt, and the ſhagreened hair ſide outwards; after which they are dipped three times in the remains of an exhauſted kettle of the ſame dye, the ſuperfluous dye being each time expreſſed; and after this proceſs they are dipped in the freſh dye prepared as above, which muſt not be expreſſed. The ſkins are then hung up in the ſhade to dry; after which they are cleaned and paired at the edges.

"For black ſhagreen, gall-nuts and vitriol are employed in the following manner:—The ſkins, moiſt from the pickle, are thickly beſtrewed with finely pulveriſed gall-nuts. They are then folded together, and laid over each other for 24 hours. A new ley, of bitter ſaline earth or *ſchora*, is in the mean time prepared, and poured hot into ſmall troughs. In this ley each ſkin is ſeveral times dipped; after which they are again beſtrewed with pounded gall-nuts, and placed in heaps for a certain period, that the galls may thoroughly penetrate them, and they are dried and beat, to free them from the duſt of the galls. When this is done, they are rubbed over, on the ſhagreen ſide, with melted ſheep's tallow, and expoſed a little in the ſun, that they may imbibe the greaſe. The ſhagreen-makers are accuſtomed alſo to roll up each ſkin ſeparately, and to preſs or ſqueeze it with their hands againſt ſome hard ſubſtance, in order to promote the abſorption of the tallow. The ſuperfluous particles are removed by means of a blunt wooden ſcraper (*urac*): and when this proceſs is finiſhed, and the ſkins have lain ſome time, a ſufficient quantity of vitriol of iron is diſſolved in water, with which the ſhagreen is moiſtened on both ſides, and by this operation it acquires a beautiful black dye. It is then dreſſed at the edges, and in other places where there are any blemiſhes.

"To obtain white ſhagreen, the ſkins muſt firſt be moiſtened on the ſhagreen ſide with a ſtrong ſolution of alum. When the ſkin has imbibed this liquor, it is daubed over on both ſides with a paſte made of flour, which is ſuffered to dry. The paſte is then waſhed off with alum-water, and the ſkin is placed in the ſun till it is completely dry. As ſoon as it is dry, it is gently beſmeared with pure melted ſheep's tallow, which it is ſuffered to imbibe in the ſun; and to promote the effect, it is preſſed and worked with the hands. The ſkins are then faſtened in ſucceſſion to the before mentioned bench, where warm water is poured over them, and the ſuperfluous fat is ſcraped off with a blunt wooden inſtrument. In the laſt operation the warm water is of great ſervice. In this manner ſhagreen perfectly white is obtained, and nothing remains but to pare the edges and dreſs it.

"But this white ſhagreen is not intended ſo much for

for remaining in that ſtate, as for receiving a dark red dye; becauſe, by the above previous proceſs, the colour becomes much more perfect. The ſkins deſtined for a red colour muſt not be immerſed firſt in ley of bitter ſalt earth (*ſchora*), and then in pickle, but after they have been whitened, muſt be left to ſoak in the pickle for 24 hours. The dye is prepared from cochineal, which the Tartars call *kirmitz*. About a pound of the dried herb *tſchagann*, which grows in great abundance in the neighbourhood of Aſtracan, and is a kind of ſoda plant or kali (*ſalſola ericoides* (A), is boiled a full hour in a kettle containing about four common pailfuls of water; by which means the water acquires a greeniſh colour. The herb is then taken out, and about half a pound of pounded cochineal is put into the kettle, and the liquor is left to boil a full hour, care being taken to ſtir it that it may not run over. About 15 or 20 drams of a ſubſtance which the dyers call *lüter* (orchilla) is added, and when the liquor has been boiled for ſome time longer, the kettle is removed from the fire. The ſkins taken from the pickle are then placed over each other in troughs, and the dye-liquor is poured over them four different times, and rubbed into them with the hands, that the colour may be equally imbibed and diffuſed. The liquor each time is expreſſed; after which they are fit for being dried. Skins prepared in this manner are ſold at a much dearer rate than any of the other kinds."

SHARP (Abraham), an eminent mathematician, mechaniſt, and aſtronomer, was deſcended from an ancient family at Little Horton, near Bradford, in the Weſt Riding of Yorkſhire, where he was born about the year 1651. At a proper age he was put apprentice to a merchant at Mancheſter; but his genius led him ſo ſtrongly to the ſtudy of mathematics, both theoretical and practical, that he ſoon became uneaſy in that ſituation of life. By the mutual conſent, therefore, of his maſter and himſelf, though not altogether with that of his father, he quitted the buſineſs of a merchant. Upon this he removed to Liverpool, where he gave himſelf up wholly to the ſtudy of mathematics, aſtronomy, &c.; and where, for a ſubſiſtence, he opened a ſchool, and taught writing and accounts, &c.

He had not been long at Liverpool when he accidentally fell in company with a merchant or tradeſman viſiting that town from London, in whoſe houſe it ſeems the aſtronomer Mr Flamſteed then lodged. With the view therefore of becoming acquainted with this eminent man, Mr Sharp engaged himſelf with the merchant as a book-keeper. In conſequence he ſoon contracted an intimate acquaintance and friendſhip with Mr Flamſteed, by whoſe intereſt and recommendation he obtained a more profitable employment in the dock-yard at Chatham; where he continued till his friend and patron, knowing his great merit in aſtronomy and mechanics, called him to his aſſiſtance, in contriving, adapting, and fitting up the aſtronomical apparatus in the Royal Obſervatory at Greenwich, which had been lately built, namely, about the year 1676. He was principally employed in the conſtruction of the mural arch; which in the compaſs of 14 months he finiſhed ſo greatly to the ſatisfaction of Mr Flamſteed, that he ſpeaks of him in terms of the higheſt praiſe. According to Mr Smeaton, this was the firſt good and valid inſtrument of the kind; and Mr Sharp the firſt artiſt who cut accurate and delicate diviſions upon aſtronomical inſtruments. At the time this inſtrument was conſtructed, Mr Flamſteed was 30 and Mr Sharp 25 years of age.

Theſe two friends continued together for ſome time, making obſervations on the meridional zenith diſtances of the fixed ſtars, ſun, moon, and planets, with the times of their tranſits over the meridian; alſo the diameters of the ſun and moon, and their eclipſes, with thoſe of Jupiter's ſatellites, the variation of the compaſs, &c.

Mr Sharp aſſiſted Mr Flamſteed alſo in making a catalogue of near 3000 fixed ſtars, with their longitudes and magnitudes, their right aſcenſions and polar diſtances, with the variations of the ſame while they change their longitude by one degree.

But from the fatigue of continually obſerving the ſtars at night, in a cold thin air, joined to a weakly conſtitution, he was reduced to a bad ſtate of health; for the recovery of which he deſired leave to retire to his houſe at Horton; where, as ſoon as he found himſelf on the recovery, he began to fit up an obſervatory of his own; having firſt made an elegant and curious engine for turning all kinds of work in wood or braſs, with a maundril for turning irregular figures, as ovals, roſes, wreathed pillars, &c. Beſide theſe, he made himſelf moſt of the tools uſed by joiners, clockmakers, opticians, mathematical inſtrument makers, &c. The limbs or arcs of his large equatorial inſtrument, ſextant, quadrant, &c. he graduated with the niceſt accuracy, by diagonal diviſions into degrees and minutes. The teleſcopes he made uſe of were all of his own making, and the lenſes ground, figured, and adjuſted with his own hands.

It was at this time that he aſſiſted Mr Flamſteed in calculating moſt of the tables in the ſecond volume of his *Hiſtoria Cœleſtis*, as appears by their letters, to be ſeen in the hands of Mr Sharp's friends at Horton. Likewiſe the curious drawings of the charts of all the conſtellations viſible in our hemiſphere, with the ſtill more excellent drawings of the planiſpheres both of the northern and ſouthern conſtellations. And though theſe drawings of the conſtellations were ſent to be engraved at Amſterdam by a maſterly hand, yet the originals far exceeded the engravings in point of beauty and elegance: theſe were publiſhed by Mr Flamſteed, and both copies may be ſeen at Horton.

The mathematician, ſays Dr Hutton, meets with ſomething extraordinary in Sharp's elaborate treatiſe of *Geometry Improved* (in 4to, 1717, ſigned A. S. Philomath): 1ſt, by a large and accurate table of ſegments of circles, its conſtruction and various uſes in the ſolution of ſeveral difficult problems, with compendious tables for

(A) The beautiful red Turkey leather is dyed with cochineal prepared in the ſame manner. Profeſſor Gmelin junior, in the ſecond part of his Travels through Ruſſia, explains the herb *tſchagann* by *artemiſia annua*, having doubtleſs been deceived by the appearance the plant acquires after it has been dried. Beſides, this *artemiſia* is found only in the middle of Siberia, and never on the weſt ſide of the Irtiſch.

for finding a true proportional part; and their ufe in thefe or any other tables exemplified in making logarithms, or their natural numbers, to 60 places of figures; there being a table of them for all primes to 1100, true to 61 figures. 2d, His concife treatife of Polyedra, or folid bodies of many bafes, both the regular ones and others: to which are added twelve new ones, with various methods of forming them, and their exact dimenfions in furds, or fpecies, and in numbers; illuftrated with a variety of copperplates, neatly engraved by his own hands. Alfo the models of thefe polyedra he cut out in boxwood with amazing neatnefs and accuracy. Indeed few or none of the mathematical inftrument makers could exceed him in exactly graduating or neatly engraving any mathematical or aftronomical inftrument, as may be feen in the equatorial inftrument above mentioned, or in his fextant, quadrants, and dials of various forts; alfo in a curious armillary fphere, which, befide the common properties, has moveable circles, &c. for exhibiting and refolving all fpherical triangles; alfo his double fector, with many other inftruments, all contrived, graduated, and finifhed, in a moft elegant manner, by himfelf. In fhort, he poffeffed at once a remarkably clear head for contriving, and an extraordinary hand for executing, any thing, not only in mechanics, but likewife in drawing, writing, and making the moft exact and beautiful fchemes or figures in all his calculations and geometrical conftructions.

The quadrature of the circle was undertaken by him for his own private amufement in the year 1699, deduced from two different feries, by which the truth of it was proved to 72 places of figures; as may be feen in the introduction to Sherwin's Tables of Logarithms; that is, if the diameter of a circle be 1, the circumference will be found equal to 3·141592653589793238 46264338327950288419716939937510582097494459230781640 5, &c. In the fame book of Sherwin's may alfo be feen his ingenious improvements on the making of logarithms, and the conftructing of the natural fines, tangents, and fecants.

He alfo calculated the natural and logarithmic fines, tangents, and fecants, to every fecond in the firft minute of the quadrant; the laborious inveftigation of which may probably be feen in the archives of the Royal Society, as they were prefented to Mr Patrick Murdoch for that purpofe; exhibiting his very neat and accurate manner of writing and arranging his figures, not to be equalled perhaps by the beft penman now living.

Mr Sharp kept up a correfpondence by letters with moft of the eminent mathematicians and aftronomers of his time, as Mr Flamfteed, Sir Ifaac Newton, Dr Halley, Dr Wallis, Mr Hodgfon, Mr Sherwin, &c. the anfwers to which letters are all written upon the backs, or empty fpaces, of the letters he received, in a fhorthand of his own contrivance. From a great variety of letters (of which a large cheftful remain with his friends) from thefe and many other celebrated mathematicians, it is evident that Mr Sharp fpared neither pains nor time to promote real fcience. Indeed, being one of the moft accurate and indefatigable computers that ever exifted, he was for many years the common refource for Mr Flamfteed, Sir Jonas Moore, Dr Halley, and others, in all forts of troublefome and delicate calculations.

Mr Sharp continued all his life a bachelor, and fpent his time as reclufe as a hermit. He was of a middle ftature, but very thin, being of a weakly conftitution. He was remarkably feeble the laft three or four years before he died, which was on the 18th of July 1742, in the 91ft year of his age.

In his retirement at Little Horton, he employed four or five rooms or apartments in his houfe for different purpofes, into which none of his family could poffibly enter at any time without his permiffion. He was feldom vifited by any perfons, except two gentlemen of Bradford, the one a mathematician, and the other an ingenious apothecary; thefe were admitted, when he chofe to be feen by them, by the fignal of rubbing a ftone againft a certain part of the outfide wall of the houfe. He duly attended the diffenting chapel at Bradford, of which he was a member, every Sunday; at which time he took care to be provided with plenty of halfpence, which he very charitably fuffered to be taken fingly out of his hand, held behind him during his walk to the chapel, by a number of poor people who followed him, without his ever looking back, or afking a fingle queftion.

Mr Sharp was very irregular as to his meals, and remarkably fparing in his diet; which he frequently took in the following manner. A little fquare hole, fomething like a window, made a communication between the room where he was ufually employed in calculations, and another chamber or room in the houfe where a fervant could enter; and before this hole he had contrived a fliding board: the fervant always placed his victuals in this hole, without fpeaking or making any the leaft noife; and when he had a little leifure, he vifited his cupboard to fee what it afforded to fatisfy his hunger or thirft. But it often happened, that the breakfaft, dinner, and fupper, have remained untouched by him, when the fervant has gone to remove what was left—fo deeply engaged had he been in calculations.

SHARPS in flour, the finer part of what we have denominated Pollards. See that article, *Suppl.*

SHASTAH, the fame as Shaster; which fee, *Encycl.*

SHEA, the name of a tree, from the fruit of which the Negroes, in the interior parts of Africa between the tropics, prepare a kind of vegetable butter. Thefe trees are not planted by the natives, but are found growing naturally in the woods; and in clearing wood land for cultivation, every tree is cut down but the Shea. The tree itfelf very much refembles the American oak; and the fruit, from the kernel of which being firft dried in the fun the butter is prepared, by boiling the kernel in water, has fomewhat the appearance of a Spanifh olive. The kernel is enveloped in a fweet pulp, under a thin green rind; and the butter produced from it, befides the advantage of its keeping the whole year without falt, is whiter, firmer, and, Mr Park fays, to his palate, of a richer flavour than the beft butter which he ever tafted made from cows milk. The growth and preparation of this commodity, feem to be among the firft objects of African induftry in this and the neighbouring ftates; and it conftitutes a main article of their inland commerce. In fome places they dry the fruit in kilns, containing each about half a cart load of fruit, under which is kept up a clear wood fire. Our author, who faw the fruit in one of thefe kilns, was informed, that in three days the fruit would

would be ready for pounding and boiling; and that the butter thus manufactured is preferable to that which is prepared from fruit dried in the sun; especially in the rainy season, when the process by insolation is always tedious, and oftentimes ineffectual. Might it not be worth while, if practicable, to cultivate Shea-trees in some of our West India islands?

SHEAVE, in mechanics, a solid cylindrical wheel, fixed in a channel, and moveable about an axis, as being used to raise or increase the mechanical powers applied to remove any body.

SHEBBEARE (John) was born at Bideford, a considerable sea port and corporation town in Devonshire, in the year 1709. His father was an attorney; but having small practice and little fortune, he carried on also the business of a corn-factor. He had four children, two sons and two daughters. Of the sons, John, the subject of our present memoir, was the eldest. The other son was called Richard, and entirely the reverse of his brother in disposition; he was bred to the sea, and died young.

John received the rudiments of his education at the free grammar school of Exeter, then conducted by the learned Mr Zachary Mudge (author of an Essay for a new Version of the Psalms, and a volume of excellent Sermons), afterwards Rector of St Andrew in Plymouth. It has oftentimes been remarked, that the future life of a man may be nearly guessed at from his puerile character. Thus Shebbeare, while a schoolboy, gave the strongest indications of his future eminence in misanthropy and literature, by the remarkable tenaciousness of his memory, and the readiness of his wit, and no less so by the malignity of his disposition; being universally considered as a lad of surprising genius, while at the same time he was as generally despised for his malicious and ungrateful temper. This may easily be believed, when it is said, that he formed not one connection, either at school or afterwards, with any person in the way of friendship, except with a young barber of an abandoned character, but whose soul was perfectly congenial to that of Shebbeare's.

Such is the account of Shebbeare's boyish years which we have in the 14th volume of the *European Magazine*. It is probably much exaggerated; for Shebbeare continued through life a staunch Tory, if not a Jacobite; and it is well known that many of our journalists consider themselves as at liberty to give what characters they please of such men.

In the fifteenth or sixteenth year of his age, young Shebbeare was bound apprentice to a very eminent and worthy surgeon in his native town; in which situation he acquired a considerable share of medical knowledge. His genius for lampoon appeared at this early period, and he could nor forbear from exercising it on his master. No one indeed could give him the slightest offence with impunity; for which reason almost every person avoided his acquaintance, as we would avoid the caressing of an adder. The chief marks, however, of the arrows of his wit were the gentlemen of the corporation: one or other, and sometimes all of them, were almost constantly exposed in a libel upon the public posts and corners of the streets. But though the wiser part of them only laughed at these harmless trifles, yet some were more irritable, and many a prosecution was commenced against, but not one could fix itself upon him, so artfully had he contrived to conceal himself. He was also several times summoned to appear at the sessions, for daring to speak and write irreverently of the worshipful magistrates; but the laugh was always on the side of Shebbeare, nor could they ever come at his back, so closely had he fitted on his armour, with the whip of authority.

When he was out of his time he set up trade for himself, and then shewed a taste for chemistry; and soon after he married a very agreeable and amiable young woman, of no fortune, but of a genteel family. Whether his insuperable propensity to satire deprived him of friends and of business, or that he spent too much in chemical experiments, we know not; but failing at Bideford, he removed, about the year 1736, to Bristol, where he entered into partnership with a chemist, and never afterwards set his foot in his native town.

In the year 1739 he attracted the attention of the public, by an epitaph to the memory of Thomas Coster, Esq. member for Bristol; in which, it has been truly observed, that he has contrived to raise emotions of pity, grief, and indignation, to a very high degree. The next year he published a pamphlet on the Bristol waters; from which period there is a chasm in our author's life we are unable to fill up. In this interval may probably be placed his failure in business, and his effort to obtain a higher situation in his profession. It is certain that in the year 1752 he was at Paris, and there he obtained the degree, if he obtained it at all, which gave him the addition to his name which accompanied him during the rest of his life, that of Doctor. Until this time he appears to have lived in obscurity; but at an age when vigorous exertion usually subsides, he seems to have resolved to place himself in a conspicuous situation, whatever hazard might attend it, and commenced a public writer with a degree of celerity and virulence for which it would be difficult to find a parallel even in the most temperate times. To read over his works now, when the passions they then raised have subsided, we feel surprise at the effect they produced; and it is within the memory of many yet living, that their influence was very considerable. In the year 1754, he began his career with The Marriage Act, a political novel; in which he treated the legislature with such freedom, that it occasioned his being taken into custody, from whence, however, he was soon released.

The performances, however, most celebrated, were a series of Letters to the People of England, which were written in a style vigorous and energetic, though slovenly and careless, well calculated to make an impression on common readers; and were accordingly read with avidity, and circulated with diligence. They had a very considerable effect on the minds of the people, and galled the ministry, who seem to have been at first too eager to punish the author. On the publication of the Third Letter, we find warrants, dated 4th and 8th of March, 1756, issued by Lord Holdernesse, to take up both Scott the publisher and the author. This prosecution, however, seems to have been dropt, and the culprit proceeded for some time unmolested, "having declared (says one of his answerers) that he would write himself into a post or into the pillory; in the last of which he at length succeeded." On the 12th of January 1758, a general warrant was signed by Lord Holdernesse, to search for the author, printer, Shebbeare. printer, and publishers of a wicked, audacious, and treasonable libel, entitled, "A Sixth Letter to the People of England, on the progress of national ruin; in which is shewn that the present grandeur of France and calamities of this nation are owing to the influence of Hanover on the councils of England;" and them having found, to seize and apprehend, together with their books and papers.

At this juncture government seem to have been effectually roused; for having received information that a seventh letter was printing, by virtue of another warrant, dated January 23, all the copies were seized and entirely suppressed. In Easter Term an information was filed against him by Mr Pratt, then attorney general, afterwards Lord Camden; in which it is now worthy of remark, that the crown officer, in his application to the court, in express terms admitted a point, since much disputed, that of the jury's right to determine both the law and the fact in matters of libel. "What I urge (says the advocate) to the court, is only to shew there is reasonable ground for considering this publication as a libel, and for putting it in a way of trial, and therefore it is I pray to have the rule made absolute; for I admit, and your lordship well knows, that the jury in matter of libel are judges of the law as well as the fact, and have an undoubted right to consider whether, upon the whole, the pamphlet in question be, or be not, a false, malicious, and scandalous libel." On the 17th of June, the information was tried, when our author was found guilty; and on the 28th November he received sentence, by which he was fined five pounds, ordered to stand in the pillory December 5, at Charing Cross, to be confined three years, and to give security for his good behaviour for seven years, himself in 500l. and two others in 250l. each.

On the day appointed, that part of the sentence which doomed him to the pillory was put in execution, amidst a prodigious concourse of people assembled on the occasion. The under sheriff, at that time, happened to be Mr Beardmore, who had sometimes been assisted by the Doctor in writing the Monitor, a paper in its principles of the same tendency with the writings of the culprit, who consequently might expect every indulgence from the officer to whom the execution of his sentence was committed. The manner in which it was conducted may be learned from the affidavits on which afterwards the under sheriff's conduct became the subject of animadversion in the court of King's Bench, and which assert, "that the defendant only stood upon the platform of the pillory, unconfined, and at his ease, attended by a servant in livery (which servant and livery were hired for the occasion only) holding an umbrella over head all the time: but his head, hands, neck, and arms, were not at all confined, or put into the holes of the pillory; only that he sometimes put his hands upon the holes of the pillory in order to rest himself." For this neglect of duty, Beardmore was fined 50l. and suffered two months imprisonment.

Some time before he was tried for the obnoxious publication already mentioned, the Duchess of Queensbury, as heir of Lord Clarendon, obtained an injunction in the Court of Chancery to stop the publication of the continuation of that nobleman's history; a copy of which had got into the hands of Francis Gwyn, Esq. between whom and the Doctor there had been an agreement to publish it and equally divide the profits. The care and expences attending the ushering this work into the world were to be wholly Dr Shebbeare's, who performed his part of the agreement, and caused it to be handsomely printed in quarto, with a Tory preface, containing frequent reflections on, and allusions to recent events, and to living characters, which gave it the appearance rather of a temporary pamphlet than of a work calculated for posterity. On the injunction being obtained, Dr Shebbeare was under the necessity of applying to the aid of law to recover the money expended by him in printing, amounting to more than 500l. Of that sum more than half had been wasted on his side in the courts of law and equity. And some years afterwards, speaking of the situation of his affairs, he says, "It may be easily imagined, that my circumstances were not improved by three years imprisonment. I had no club of partizans to maintain me during that time, to discharge my debts, nor even the fine, which I was obliged to pay after a three years confinement for a single offence. Notwithstanding the difficulties which inevitably arose from these particulars, and although an insolvent act was passed soon after his Majesty's accession to the throne, and my circumstances might have apologised for my taking that opportunity which it offered; I nevertheless declined from availing myself of that occasion to evade the payment of my debts. I preferred the labour of endeavouring to pay them, and the risk of being again imprisoned if I did not succeed. But, thank Heaven, I am in no danger of a second imprisonment on that account." During his confinement, he declares he never received as presents more than twenty guines from all the world.

While he was confined in the King's Bench, he solicited subscriptions for the first volume of a History of England, from the Revolution to the then present time. But at the persuasion of his friends he was induced to alter his design, and receipts were issued for a first volume of the History of England, and of the Constitution thereof from its origin. That volume he wrote, and had transcribed. "But as it was impracticable (to use his own words), whilst I was in confinement, to procure that variety of books, or to apply to manuscript authorities, for all that was requisite to the completing of this first volume, I found on being released from my imprisonment, and on application to the former only, that the volume which I had written was incorrect, insufficient, and erroneous, in too many particulars, to admit of its being published, without injustice to my subscribers, and reprehensions on myself. Into this displeasing situation I had been misled by relying on the authorities of modern historians, who pretend to cite the authors from whence their materials are taken, many of whom appear never to have seen them, but implicitly to have copied one another, and all of them manifestly defective; not only in the authorities they should have sought, but in their omissions and misrepresentations of those whom they had consulted: more especially respecting those parts of the old German codes, on which our constitution is erected, and without which it cannot be properly explained or understood. Such being the real situation of things, I perceived that more time than I could expect to live would be necessarily required for so extensive a work as the

Shebbeare.

the whole hiftory I had propofed; and that a fingle volume, or even a few volumes of an hiftory incomplete, would by no means anfwer either the intention of my fubfcribers, or my own: I determined therefore to change my plan, and to include in one volume that which might require no others to complete this new defign.

"In confequence of this alteration, I refolved to exert my beft abilities, not only to trace the conftitution of England from its origin in the woods of Germany, as M. de Montefquieu expreffes it, but from the firft principles of human nature, from which the formation of all kinds of government is derived. With this view, I have attempted an analyzation of the mental and corporeal faculties, in order to fhew in what manner they reciprocally influence each other in the various actions of man, not only as an individual, but as a gregarious being, impelled by nature to affociate in communities. From hence I have attempted to delineate in what manner legiflature fprang and proceeded from its fource, through that variety of meanders which it hath formed in its current, both before and fince the introduction of one common fign, whereby to exprefs the intrinfic value, not only of all the productions of nature and of art, but even of the human faculties, as they are now eftimated; to compare the conftitutions of thofe different ftates which have been, and are the moft celebrated in ancient and modern hiftory, with each other, and with that of England; and then to derive fome reafonable grounds for the determination of that which feems to be the moft confentaneous with the primogenial inftitutes of nature, and the happinefs of human kind. In confequence of this intent, the manners that fucceffively arofe and prevailed in fuch ftates, the benefits and mifchiefs which enfued from them, are delineated, in order to explain on what foundation the welfare of national communities may moft probably be eftablifhed."

This plan, thus delineated, he at times employed himfelf in filling up; but on being rudely attacked for not performing his promife with his fubfcribers, he, in 1774, obferved—"From the inevitable obligations, not only of fupporting my own family, but thofe alfo whom as fon and brother it was my duty to fuftain for forty years, and which, refpecting the claims of the latter, ftill continues; it will be eafily difcerned that many an avocation muft have proceeded from thefe circumftances, as well as from a fenfe of gratitude to his majefty, in defence of whofe government I have thought it my duty occafionally to exert my beft abilities." He adds, however, that he did not intend to die until what he had propofed was finifhed; a promife which the event has fhewn he was unable to perform.

In prifon he was detained during the whole time of the fentence, and with fome degree of rigour; for when his life was in danger from an ill ftate of health, and he applied to the court of King's Bench for permiffion to be carried into the rules a few hours in a day, tho' Lord Mansfield acceded to the petition, yet the prayer of it was denied and defeated by Judge Fofter. At the expiration of the time of his fentence, a new reign had commenced; and fhortly afterwards, during the adminiftration of Mr Grenville, a penfion was granted him by the crown. This he obtained by the perfonal application of Sir John Philips to the King, who, on that occafion, was pleafed to fpeak of him in very favourable terms, which he promifed undeviatingly to endeavour to deferve by allegiance and gratitude.

Shebbeare.

From the time of that event we find Dr Shebbeare a uniform defender of the meafures of Government, and the mark againft whom every oppofer of adminiftration confidered himfelf at liberty to throw out the groffeft abufe. Even the friends of power were often adverfe to him. Dr Smollet introduced him in no very refpectful light, under the name of Ferret, in the novel of Sir Launcelot Greaves, and Mr Hogarth made him one of the group in the third election print.

Scarce a periodical publication was without fome abufe of him, which he feems to have in general had the good fenfe to neglect. In the year 1774, however, he departed from his general practice, and defended himfelf from fome attacks at that time made upon him. In this pamphlet he reprefented the conduct and character of King William in fuch a light as to excite the indignation of every Whig in the kingdom: he treated him in print with as great feverity as Johnfon ufed to do in converfation.

Early in life he appears to have written a comedy, which in 1766 he made an effort to get reprefented at Covent Garden. In 1768 he wrote the Review of Books in the Political Regifter for three months, and was often engaged to write for particular perfons, with whom he frequently quarrelled when he came to be paid. This was the cafe with Sir Robert Fletcher, and we think of others. His pen feems to have been conftantly employed, and he wrote with great rapidity, what certainly can now be read with little fatisfaction, and muft foon be forgotten. Though penfioned by government, he can fcarce be faid to have renounced his opinions; for in the pamphlet already mentioned, his abufe of the Revolution is as grofs as in that for which he fuffered the pillory. His violence defeated his own purpofe, and made thofe who agreed in party with him revolt from the virulence with which he treated his adverfaries. During the latter years of his life he feems to have written but little. He was a ftrenuous fupporter of the miniftry during the American war, having publifhed, in 1775, An Anfwer to the printed Speech of Edmund Burke, Efq; fpoken in the Houfe of Commons, April 19, 1774. In which his knowledge in polity, legiflature, human kind, hiftory, commerce, and finance, is candidly examined; his arguments re fairly refuted; the conduct of adminiftration is fully defended; and his oratoric talents are clearly expofed to view.—And An Effay on the Origin, Progrefs, and Eftablifhment of National Society; in which the principles of Government, the definitions of phyfical, moral, civil, and religious Liberty contained in Dr Price's Obfervations, &c. are fairly examined, and fully refuted; together with a juftification of the Legiflature in reducing America to obedience by force. To which is added, an Appendix on the Excellent and Admirable in Mr Burke's fecond printed Speech of the 22d of March 1775, both 8vo.

His publications, fatirical, political, and medical, amount to thirty-four, befides a novel, entitled Lydia, or Filial Piety; in which religious hypocrify and bluftering courage are very properly chaftifed. He died on the 1ft of Auguft 1788, leaving, among thofe who knew him beft, the character of a benevolent man; a character

character which, from the manner in which he ſpeaks of his connections, he probably deſerved.

SHEERS, aboard a ſhip, an engine uſed to hoiſt or diſplace the lower maſts of a ſhip.

SHEIBON, a diſtrict in Africa, lying to the ſouth-eaſt of the kingdom of Dar-Fur (See SOUDAN in this volume), where much gold is found both in duſt and in ſmall pieces. The natives, who are idolaters and ſavages, collect the duſt in quills of the oſtrich and vulture, and in that condition ſell it to the merchants. They have a ceremony on diſcovering a large piece of gold, of killing a ſheep on it before they remove it. The people, who are all black, have ſome form of marriage, *i. e.* of an agreement between man and woman to cohabit. Women of full age wear a piece of plaited graſs on their parts. The younger and unmarried are quite naked. The ſlaves, which are brought in great numbers from this quarter, are ſome priſoners of war among themſelves (for their wars are frequent), and ſome ſeduced by treachery, and ſold. But it is ſaid to be a common practice for a father in time of ſcarcity to ſell his children.

At Sheibon are ſome Mahommedans, who live among the idolaters, and wear clothing: it is not ſaid whether Arabs or not. Mr Browne, from whoſe travels we have taken this account of Sheibon, does not give its latitude or longitude.

SHILLUK, a town in Africa on the banks of the Bahr-el-abiad, or true Nile. The houſes are built of clay, and the inhabitants, who are idolaters, have no other clothing than bands of long graſs, which they paſs round the waiſt and between the thighs. They are all black; both ſexes are accuſtomed to ſhave their heads. The people of Shilluk have the dominion of the river, and take toll of all paſſengers, in ſuch articles of traffick as paſs among them. The name Shilluk is not Arabic, and its meaning is unknown.—When aſked concerning their name or country, the people reply Shilluk. When employed in tranſporting Mahommedans acroſs the ferry, they occaſionally exhibit the importance which their ſituation gives them. After the Muſlim has placed himſelf in the boat, they will aſk him, "Who is the maſter of that river?" The other replies, as is uſual, "Ullah or Rubbani"—God is the maſter of it. "No (anſwers the Shilluk), you muſt ſay that ſuch a one (naming his chief) is the maſter of it, or you ſhall not paſs." They are repreſented as ſhewing hoſpitality to ſuch as come among them in a peaceable manner, and as never betraying thoſe to whom they have once accorded protection. The particulars of their worſhip have not been deſcribed. In Mr Browne's map, Shilluck is placed in about 13° N. Lat. and 32° 26′ E. Long.

SHIP. See that article, and SHIPBUILDING (*Encycl.*), and likewiſe FLOATING *Bodies* (*Suppl.*) In the *Tranſactions of the Royal Society of London* for 1798, Mr Atwood has completed his diſquiſition on the *Stability* of Ships; but as the memoir cannot be abridged, we muſt refer the ſcientific naval architect to the original for much uſeful information.

A ſmall work has lately been publiſhed by Charles Gore, Eſq: of Weimar in Saxony, upon *the reſpective Velocity of Floating Bodies varying in Form.* It contains merely the reſults of two ſeries of experiments: from the firſt of which ſeries, it ſeems to appear that the form beſt calculated for velocity is a long parallel body, terminating at each end in a parabolic cuneus, and having the extreme breadth in the centre. Alſo, that making the cuneus more obtuſe than is neceſſary to break with fairneſs the curve line into the ſtraight, creates a conſiderable degree of impediment. And Mr Gore is inclined to think, that the length of ſhips, which has already been extended with ſucceſs, to four times the breadth, is capable, with advantage, of ſtill further extenſion, perhaps to five, and, in ſome caſes, even to ſix times.

The ſecond ſet of experiments was inſtituted to aſcertain the reſpective degrees of ſtability, or power of reſiſting the preſſure of the wind, in carrying ſail, on bodies of different forms. The bodies uſed in the experiments had their ſpecific capacities and weights preciſely equal, but their forms different; and from the reſults, it appears that the form of a midſhip body, beſt adapted for ſtability only, is a flat bottom, with perpendicular ſides; and that the next beſt adapted is a ſemicircle. But as there exiſts much difficulty in conſtructing the former with ſufficient ſtrength, beſides its being ill adapted to heavy ſeas, as, by the ſudden deſcent in pitching, the bottom will ſtrike the water nearly at right angles, and ſuſtain thereby a tremendous ſhock. And as the latter ſeems to be too inclinable to tranſverſe oſcillation, or rolling, and alſo to be deficient in capacity for many ſervices, our author is of opinion, that a midſhip body, of a compounded form, is moſt applicable to general purpoſes.

On account of the few documents before us, we are unable to ſpeak critically concerning this tract. To benefit naval architecture, we are of opinion, that the method of experiment is more ſure and expeditious than that of calculation: yet concluſions from experiments muſt be drawn with great caution. It is by no means certain that a reſult obtained for a body of a given bulk will obtain for ſimilar bodies which differ in dimenſions.

We ſhall conclude this ſhort article with a ſtatement of the principles upon which Patrick Miller, Eſq; of Dalſwinton (Scotland), propoſes to conſtruct ſhips and veſſels which cannot founder.

The veſſel is to be kept afloat, without the aid of its ſides, ſolely by the buoyancy of its bottom, which is flat; the bottom never being ſo deeply immerſed as to bring the upper ſurface thereof on a level with the water; ſuch veſſels not being conſtructed for the purpoſe of carrying cargoes, but for that of carrying paſſengers, with the neceſſary ſtores and proviſions; and as theſe veſſels are not kept afloat by the aid of their ſides, but by the buoyancy of their bottom, as above deſcribed, they cannot ſink, and therefore pumps are not required, nor are they in any reſpect neceſſary for the preſervation of ſuch veſſels. The ſaid veſſel is put in motion, during calms, and againſt light winds, by means of wheels. Theſe wheels project beyond the ſides of the veſſel, and are wrought by means of capſtans: the number and the dimenſions of the wheels depend upon the length of the veſſel. Theſe wheels are built with eight arms, which conſiſt entirely of plank. Sliders are uſed to work and to keep the veſſel to windward when under ſail. Theſe ſliders are placed in the centre of the veſſel, from ſtem to ſtern; they are made of plank, and the number and dimenſions muſt depend on the length of the veſſel; and they are raiſed and let

down,

down, either by the hand, or by means of a purchase, according to the size of the vessel. Vessels of this construction draw water, in proportion to their dimensions, as follows: a vessel of forty feet in length, and from thirteen to nineteen feet in breadth, will draw from thirteen to sixteen inches of water. One of fifty feet in length, and from seventeen to twenty-four feet in breadth, will draw from fifteen to eighteen inches of water. One sixty feet long, and from twenty to twenty-eight feet broad, will draw from eighteen to twenty-one inches of water. One seventy feet long, and from twenty-three to thirty two feet broad, will draw from twenty one to twenty-four inches of water. One eighty feet long, and from twenty-seven to thirty-seven feet broad, will draw from twenty-four to twenty seven inches of water. One ninety feet long, and from thirty to forty two feet broad, will draw from twenty seven to thirty inches of water. One of one hundred feet in length, and from thirty-three to forty-seven feet in breadth, will draw from thirty to thirty-three inches of water.

As, from the principle upon which this vessel is constructed, she cannot sink, the invention must prove a means of saving many lives; and as it will give more room and height between the decks than any vessel of the same dimensions of another construction, it must add greatly to the comfort and accommodation of persons at sea of all descriptions. It is expected that, from these advantages, a more general and friendly intercourse amongst nations will take place, which will have the effect to diffuse knowledge, and to remove national prejudices, thereby promoting the general welfare of mankind. At present (says Mr Miller), it would be altogether improper to give any description of ships of greater dimensions, left it should be converted to a purpose very different from that intended by the inventor.

SHIPWRECK, a well-known disaster, by which numbers of lives are yearly lost. In that valuable miscellany entitled, *The Philosophical Magazine*, we have an account of means for preventing that loss, when the ship is in danger within two or three hundred fathoms of the shore; and as the anonymous author (a Frenchman) says that he has by experiment ascertained the efficacy of these means, we shall state them to our readers.

The only certain means of saving the crew of a vessel in such a state is, to establish a rope of communication from the shore to the ship. But how is this to be done? The author says, by fixing the end of the rope to a bomb or cannon ball, and extending the rope afterwards, in a zig-zag direction, before the mortar or cannon, or suspending it on a piece of wood raised several feet. A rope, so placed, will not break (he says) by the greatest velocity which can be given to the bomb or ball; and thus the end of it can be sent ashore by a discharge of artillery. He prefers the bomb to the cannon ball, for reasons which he does not assign. He proposes, however, other means to effect his benevolent purpose.

"It ought to be remembered (says he), that a vessel is never cast away, or perishes on the coast, but because it is driven thither against the will of the captain, and by the violence of the waves and the wind, which almost always blows from the sea towards the shore, without which there would be no danger to be apprehended: consequently, in these circumstances, the wind comes always from the sea, either directly or obliquely, and blows towards the shore.

"1*st*, A common paper kite, therefore, launched from the vessel and driven by the wind to the shore, would be sufficient to save a crew consisting of 1500 seamen, if such were the number of a ship of war. This kite would convey to the shore a strong packthread, to the end of which might be affixed a cord, to be drawn on board by means of the string of the kite; and with this cord a rope, or as many as should be necessary, might be conveyed to the ship.

"2*d*, A small balloon, of six or seven feet in diameter, and raised by rarefied air, would be also an excellent means for the like purpose: being driven by the wind from the vessel to the shore, it would carry thither a string capable of drawing a cord with which several ropes might be afterwards conveyed to the vessel. Had not the discovery of Montgolfier produced any other benefit, it would be entitled on this account to be considered as of great importance.

"3*d*, A sky-rocket, of a large diameter, would be of equal service. It would also carry, from the vessel to the shore, a string capable of drawing a rope after it.

"*Lastly*, A fourth plan for saving the crew of a shipwrecked vessel, is that of throwing from the vessel into the sea an empty cask with a cord attached to it. The wind and the waves would drive the cask to the shore, and afford the means of establishing that rope of communication already mentioned."

SILLA, a large town on the Niger, which bounded Mr Park's travels eastward. He gives no description of the place, which he had not spirits or health to survey; but fills a page of his work with the reasons which determined him to proceed no farther. "When I arrived (says he), I was suffered to remain till it was quite dark, under a tree, surrounded by hundreds of people. But their language was very different from the other parts of Bambarra; and I was informed that, in my progress eastward, the Bambarra tongue was but little understood, and that when I reached Jenné, I should find that the majority of the inhabitants spoke a different language, called *Jenné Kummo* by the Negroes, and *Kalam Soudan* by the Moors.

"With a great deal of entreaty, the Dooty allowed me to come into his balloon, to avoid the rain; but the place was very damp, and I had a smart paroxysm of fever during the night. Worn down by sickness, exhausted with hunger and fatigue, half naked, and without any article of value, by which I might procure provisions, clothes, or lodging, I began to reflect seriously on my situation. I was now convinced, by painful experience, that the obstacles to my farther progress were insurmountable. The tropical rains were already set in with all their violence; the rice grounds and swamps were everywhere overflowed; and in a few days more, travelling of every kind, unless by water, would be completely obstructed. The kowries which remained of the king of Bambarra's present were not sufficient to enable me to hire a canoe for any great distance; and I had but little hopes of subsisting by charity, in a country where the Moors have such influence. But above all, I perceived that I was advancing more and more within the power of those merciless fanatics; and from my reception both at SEGO and SANSANDING (see these articles, *Suppl.*), I was apprehensive that, in attempting to reach even Jenné (unless under the protection of some man of consequence amongst them, which I had no no means of obtaining), I should sacrifice my life to no purpose; for my discoveries would perish with me. The prospect either way was gloomy. In returning to the Gambia, a journey on foot of many hundred miles presented itself to my contemplation, through regions and countries unknown. Nevertheless, this seemed to be the only alternative; for I saw inevitable destruction in attempting to proceed to the eastward. With this conviction on my mind, I hope my readers will acknowledge that I did right in going no farther. I had made every effort to execute my mission in its fullest extent which prudence could justify. Had there been the most distant prospect of a successful termination, neither the unavoidable hardships of the journey, nor the dangers of a second captivity, should have forced me to desist. This, however, necessity compelled me to do: and whatever may be the opinion of my general readers on this point, it affords me inexpressible satisfaction, that my honourable employers have been pleased, since my return, to express their full approbation of my conduct." He would be a very unreasonable man, indeed, who could on this point think differently from Mr Park's employers. Silla is placed in the new map of Africa in about 14° 48′ N. Lat. and 1° 24′ W. Long.

SILLON, in fortification, an elevation of earth, made in the middle of the moat, to fortify it, when too broad. It is more usually called the *envelope*.

SIMANCAS, a village on the eastern limit of the kingdom of Leon in Spain, two leagues below Valladolid, on the river Gisnerga. It is mentioned by Dr Robertson in the introduction to his History of America, and is remarkable for the archives or register office of the kingdoms of Leon and Castile, kept in the castle there. This collection was begun when the kings resided often at Valladolid; in which city to this day is the chancery or civil and military tribunal for almost all Spain to the north of the Tagus. It was thought convenient to have those papers kept in the neighbourhood of that court; and this castle was particularly fit for that purpose, as it is all built of stone. Some years ago there were two large halls in this office filled with papers relating to the first settlement of the Spaniards in South America. There was also in the room called the *ancient royal patronage* a box containing treaties with England, in which are many letters and treaties between the kings of England and Spain from about the year 1400 down to 1600. There was also in the same archives a strong box, with five locks, which, it is said, has not been opened since the time of Philip II. and it is conjectured that it contains the process against Philip's son Prince Charles. But it seems some of the state papers have been removed to Madrid.

SITUS, in algebra and geometry, denotes the situation of lines, surfaces, &c. Wolfius delivers some things in geometry, which are not deduced from the common analysis, particularly matters depending on the *situs* of lines and figures. Leibnitz has even founded a particular kind of analysis upon it, called *calculus situs*.

SIWA, a town in Egypt, to the westward of Alexandria, built on a small fertile spot or Oasis, which is surrounded on all sides by desert land. A large proportion of this space is filled with date trees; but there are also pomegranates, figs, and olives, apricots, and plantains; and the gardens are remarkably flourishing. They cultivate a considerable quantity of rice, which, however, is of a reddish hue, and different from that of the Delta. The remainder of the cultivable land furnishes wheat enough for the consumption of the inhabitants. Water, both salt and fresh, abounds: but the springs which furnish the latter are most of them tepid; and such is the nature of the water, air, and other circumstances, that strangers are often affected with agues and malignant fevers.

The greatest curiosity about Siwa is a ruin of undoubted antiquity, which, according to Mr Browne, resembles too exactly those of the Upper Egypt, to leave a doubt that it was erected and adorned by the same intelligent race of men. The figures of Isis and Anubis are conspicuous among the sculptures; and the proportions are those of the Egyptian temples, though in miniature. What of it remains is a single apartment, built of massy stones, of the same kind as those of which the pyramids consist; and covered originally with six large and solid blocks, that reach from one wall to the other. The length is 32 feet in the clear, the height about 18, the width 15. A gate, situated at one extremity, forms the principal entrance; and two doors, also near that extremity, open opposite to each other. The other end is quit ruinous; but, judging from circumstances, it may be imagined that the building has never been much larger than it now is. There is no appearance of any other edifice having been attached to it, and the less so as there are remains of sculpture on the exterior of the walls. In the interior are three rows of emblematical figures, apparently designed to represent a procession; and the space between them is filled with hieroglyphic characters, properly so called. The people of Siwa have no tradition concerning this edifice, nor attribute to it any quality, but that of concealing treasures, and being the haunt of demons. It has, however, been supposed, with some degree of probability, that Siwa is the *Siropum* of Pliny, and that this building was coeval with the famous temple of Jupiter Ammon, and a dependency on it. This may be so; but neither the natives of Siwa, nor the various tribes of Arabs who frequent that place, know any thing of the ruins of that temple, about which Mr Browne made every possible enquiry. "It may (as he observes) still survive the lapse of ages, yet remain unknown to the Arabs, who traverse the wide expanse of the desert; but such a circumstance is scarcely probable. It may be completely overwhelmed in the sand; but this is hardly within the compass of belief."

The complexion of the people of Siwa is generally darker than that of the Egyptians. Their dialect is also different. They are not in the habitual use either of coffee or tobacco. Their sect is that of Malik. The dress of the lower class is very simple, they being almost naked: among those whose costume was discernible, it approaches nearer to that of the Arabs of the desert than of the Egyptians or Moors. Their clothing consists of a shirt of white cotton, with large sleeves, and reaching to the feet; a red Tunisine cap, without a turban; and shoes of the same colour. In warm weather they commonly cast on the shoulder a blue and white cloth, called in Egypt *melayé*; and in winter they are defended from the cold by an *ihhram* or blanket. The list of their household furniture is very short; some earthen ware made by themselves, and a few mats, form the chief part of it, none but the richer order being

being possessed of copper utensils. They occasionally purchase a few slaves from the Murzouk caravan. The remainder of their wants is supplied from Cairo or Alexandria, whether their dates are transported, both in a dry state and beaten into mash, which, when good, in some degree resembles a sweet meat. They eat no large quantity of animal food; and bread of the kind known to us is uncommon. Flat cakes, without leaven, kneaded, and then half baked, form part of their nourishment. The remainder consists of thin sheets of paste, fried in the oil of the palm tree, rice, milk, dates, &c. They drink in great quantities the liquor extracted from the date-tree, which they term *date-tree water*, though it have often, in the state they drink it, the power of inebriating. Their domestic animals are, the hairy sheep and goat of Egypt, the ass, and a very small number of oxen and camels. The women are veiled, as in Egypt. After the rains, the ground in the neighbourhood of Siwa is covered with salt for many weeks. Siwa is situated in 29° 12′ N. Lat. and 44° 54′ E. Long.

SKIRMISH Bay, the name given by Lieutenant Broughton to a bay in an island, which was discovered by him in latitude 43° 48′ south, and in longitude 183° east. The Chatham armed tender, which Mr Broughton commanded, under Captain Vancouver in his voyage of discovery, worked up into the bay, and came to anchor about a mile from the shore. The Lieutenant, the master, and one of the mates, landed, and found the people so extremely inhospitable, that they were obliged to fire upon them in their own defence. The land, whether island or continent, is of considerable magnitude; the part which they saw extended nearly 40 miles from east to west; and the appearance of the country, according to the description given, is very promising. In many respects, the natives resemble those of New Zealand; from which country they are distant about 100 leagues: but their skins were destitute of any marks, and they had the appearance of being cleanly in their persons. Their dresses were of seal, or sea-bear skin, and some had fine woven mats fastened round the waist. "They seemed a cheerful race, our conversation (says Mr Broughton) frequently exciting violent bursts of laughter amongst them. On our first landing their surprise and exclamations can hardly be imagined; they pointed to the sun, and then to us, as if to ask, whether we had come from thence?" Their arms were spears, clubs, and a small weapon resembling the New Zealand patoo.

SLIDING-rule (see that article, as likewise *Gauging-Rod*, Geometry, and *Logarithmic Lines*, Encycl.) is introduced here, for the sake of a new, and (except in working direct proportions) a more commodious method than the common, of applying the slider. This method, which is proposed by the Rev. W. Pearson of Lincoln, is as follows:

Invert the slider B on any common sliding rule, whereby the numerical figures will ascend on it, and on the fixed line A, in contrary directions: now, as the distance from unity to any multiplier, on Gunter's line, will invariably extend from any multiplicand to their product, it follows, that if any particular number on the inverted slider B be placed opposite to any other given number on A, the product of those numbers will stand on the slider B, against unity on A; for, in any position of the inverted slider, the distance from unity to the multiplier on A, instead of being carried forward on B, as when the slider is in a direct position, is brought back thereby to unity again; so that unity (or *ten* on single lines where the slider is too short for the operation) is invariably the index for the product of any two coincident numbers throughout the lines.

In division, by the same process, if the dividend on B be put to the index, or unity on A, the division and quotient will coincide on the two opposite lines; so that when one is given, and sought for on either line, the other is seen on its opposite line at the same time.

The next operation which offers itself here is reciprocal proportion, which can be effected by no other method than by inverting the slider, but which is rendered as easy by this application, as direct proportion is in the common way; for if any antecedent number on B inverted be set to its consequent on A, any other antecedent on B, in the same position, will stand against its consequent on A, so as that the terms may be in a reciprocal ratio. In squaring any number, it will appear from what has been already said, that if the number to be squared be placed on B, inverted against the same on A, the square will stand on B, against unity on A. Therefore, to extract the square root of any number, let that number on B stand against unity on A; and then wherever the coincident numbers are both of the same value, that point indicates the root. If two dividing lines of the same value do not exactly coincide, the coincident point will be at the middle of the space contained between those two which are nearest a coincidence; and as there is only one such point, there can be no mistake in readily ascertaining it. The finding of a mean proportional between any two numbers is extremely easy at one operation; for if one of the numbers on B inverted be set on the other on A, the coincident point of two similar numbers shews either of those to be the mean, or square root of their product, according to the preceding process. Thus have we a short and easy method of multiplying, dividing, working reciprocal proportion, squaring and extracting the square root, at one position of the inverted slider, whereby the eye is directed to only one point of view for the result, after the slider is fixed: whereas, by the common method of extracting the square root by A and B direct, the slider requires to be moved backwards and forwards by adjustment, the eye moving alternately to two points, till similar numbers stand, one on B against unity on A, and the other on A against the square number on B; which square number, in the case of finding a mean proportional, must be found by a previous operation. Hence, for more convenience in the extraction of roots, and measuring of solids, an additional line called D has been added to the rule, which renders it more complex, and consequently seldom understood by an artificer.

SNOW. See that article (*Encycl.*), where we have endeavoured to account for snow's contributing to the preservation and growth of vegetables. It must be confessed, however, that if snow possessed only the property of preserving vegetables, and of preventing them from perishing by the severity of the cold, it is not at all probable that the ancient philosophers would have considered it as depositing on the earth nitrous salts, as they might have ascertained, by a very simple experiment, Snow.

ment, that it contains none of that salt; for they did not ascribe the same property to rain-water, but they remarked that snow burnt the skin in the manner of acids, as well as other bodies immersed in it. Being induced to conclude that there was nitre in the air, it was natural that they should ascribe to this nitre the burning qualities of snow, and consequently its influence on vegetation.

Such reflections induced Morveau, *alias* Citizen Guyton, to employ J. H. Hassenfratz to inquire into the cause of the difference of the effects of snow and rain-water on various substances. Hassenfratz found that these differences are occasioned by the oxygenation of the snow; and that these effects are to be ascribed to a particular combination of oxygen in this congealed water. He put 1000 grammes of snow in a jar, and 1000 grammes of distilled water in another. He poured into each of the jars an equal quantity of the same solution of turnsole. He placed both the jars in a warm temperature; and after the snow melted, he remarked that the dye was redder in the snow water than in the distilled water. He repeated this experiment, and with the same result. He put into a jar 1000 grammes of distilled water, and into another 1000 grammes of snow. Into each of the jars he put 6·5 grammes of very pure and clean sulphat of iron. In the first, there was precipitated 0·150 grammes of the oxide of iron, and 0.010 grammes in the other. As the oxide of iron was precipitated from a solution of the sulphat by oxygen, it thence follows, that the snow contained more oxygen than the distilled water; and it follows, from the first experiment, that this quantity of oxygen was considerable enough to redden the tincture of turnsole.

It is fully demonstrated by these two experiments, that snow is oxygenated water, and that it must consequently have on vegetation an action different from that of common ice. The experiments of Dr Ingenhousz on the germination of seeds have taught us, that the presence and contact of oxygen are absolutely necessary for the plant to expand. They have shewn also, that the more abundant the oxygen is, the more rapidly will the seeds grow. Most plants suffered to attain to their perfect maturity shed on the earth a part of their seed. These seeds, thus abandoned and exposed to the action of cold, are preserved by the snow which covers them, at the same time that they find in the water it produces by melting, a portion of oxygen that has a powerful action on the principle of germination, and determines the seeds that would have perished to grow, to expand, and to augment the number of the plants that cover the surface of the earth.

A very considerable number of the plants which are employed in Europe for the nourishment of men, are sown in the months of September, October, and November. The seeds of several of these germinate before the cold commences its action upon them, and changes the principle of their life. The snow which covers the rest, acting on the germ by its oxygenation, obliges them to expand, and to increase the number of useful plants which the farmer and gardener commit to the earth, and consequently to multiply their productions.

Here, then, we have three effects of snow upon vegetation, all very different, which contribute each separately to increase, every year, the number of our plants; to give them more vigour, and consequently to multiply our crops. These effects are: 1. To prevent the plants from being attacked by the cold, and from being changed or perishing by its force. 2. To furnish vegetables with continual moisture, which helps them to procure those substances necessary for their nutrition, and to preserve them in a strong healthy state. 3. To cause a greater number of seeds to germinate, and consequently to increase the number of our plants.

Soap. Soldering.

SOAP. See CHEMISTRY-*Index*, Suppl.

SOLDERING. Under this title, in the *Encyclopædia*, we have given directions for soldering silver, brass, and iron: but there are other metals which must sometimes be soldered; and the following account of different solders, taken from the *Philosophical Magazine*, may be useful to many of our readers.

" When lead, tin, and bismuth, are mixed in a certain proportion, they produce a metal exceedingly fusible, which is known by the name of *soft solder*; but which, from its singular properties, may be applied with advantage to many other useful purposes. Newton, and after him Kraft and Muschenbroek, observed, that five parts of bismuth, three of tin, and two of lead, also five parts of bismuth, four of tin, and one part of lead, melted with a heat of 220 degrees of Fahrenheit; and they found that various mixtures of this kind were fusible by a heat not much greater than that of boiling water. At a later period, V. Rose, a German naturalist, discovered, that a mixture of four parts of bismuth, two of tin, and two of lead, as Kunkel recommended for soldering tin; and D'Arcet, among the French, that a mixture of eight parts of bismuth, three of tin, and five of lead; or eight of bismuth, four of tin, and four of lead; or eight of bismuth, two of tin, and six of lead; also sixteen of bismuth, seven of tin, and nine of lead—all melted, or at least became soft, in boiling water.

" According to the experiments made by Professor Gmelin, respecting the fusion of these three metals, a mixture, consisting of two parts of bismuth, one part of tin, and one of lead, which is the same as Rose proposed, gave a metal that was fused in boiling water. A mixture of six or more parts of bismuth, six of tin, and three of lead, or one part of bismuth, two parts of tin, and two of lead, gave, according to Klein, the solder used by the tin button-makers. The same workmen use also for soldering, according to Klein, a mixture of four parts of bismuth, three parts of tin, and five parts of lead. Among the many soft solders employed by the tin-men, a mixture of one part of bismuth, two parts of tin, and one part of lead, is, according to Klein, very much employed. Respecting this kind of solder, the experiments of Professor Gmelin give the following result: One part of bismuth, two parts of tin, and one part of lead, melt in boiling water. According to Klein, the tin-men employ for soldering a mixture of one part of bismuth, twenty-four parts of tin, and four parts of lead. Eight parts of bismuth, three of tin, and five of lead, gave a metal exceedingly like tin in its colour and brightness, but very brittle; in water beginning to boil, it became not only soft, but was completely fused. This imitation, however, may be better accomplished by the mixture of Professor Lightenberg, which consists of five parts of bismuth, Soldering, Soudan.

three of tin, and two of lead. This metal is very like the former, though not so brittle; but it seemed to melt in hot water even before it came to boil."

As this subject has again come under our notice, it may be proper to lay before our readers what M. Van Braam says of the Chinese method of soldering frying-pans and other vessels of cast-iron, when cracked and full of holes. As the author admits that it *must* appear *impossible* to those who have not *witnessed* the process, such of our artists as have not been in China will give to the tale what credit they think it deserves.

"All the apparatus of the workman consists in a little box, 16 inches long and 6 wide, and 18 inches in depth, divided into two parts. The upper contains three drawers with the necessary ingredients; in the lower is a bellows, which when a fire is wanted is adapted to a furnace eight inches long and four inches wide. The crucibles for melting the small pieces of iron intended to serve as solder are a little larger than the bowl of a common tobacco pipe, and of the same earth of which they are made in Europe: thus the whole business of soldering is executed.

"The workman receives the melted matter out of the crucible upon a piece of *wet paper*, approaches it to one of the holes or cracks in the frying-pan, and applies it there, while his assistant smooths it over by scraping the surface, and afterwards rubs it with a bit of *wet linen*. The number of crucibles which have been deemed necessary are thus successively emptied, in order to stop up all the holes with the melted iron, which consolidates and incorporates itself with the broken utensil, and which becomes as good as new. The furnace which our author saw was calculated to contain eight crucibles at a time; and while the fusion was going on, was covered with a stone, by way of increasing the intensity of the heat."—M. Van Braam affects frequently to correct the mistakes of Sir George Staunton!

SOUDAN, literally signifies the country of the negroes; but it is likewise used as one of the names of an African kingdom, otherwise called DAR-FUR. We know not that this kingdom has been visited by any European besides Mr Browne, who places it between the 11th and 16th degrees of north latitude, and between the 26th and 30th degrees of east longitude. These numbers are not exact: it does not reach so far east as the 30th degree, nor so far north as the 16th; but on his map minutes are not marked. On the north, it is bounded by a desart which separates it from Egypt; on the east, by Kordofan, which is now subject to Soudan, and lies between it and Sennaar; and on the south and east, by countries of which the names are hardly known. Mr Browne was induced to visit Soudan in hopes of being able to trace the Bahr-el-abiad, or true Nile, to its source: but he was disappointed, for that river rises in mountains considerably farther south than the limits of this kingdom; and the Sultan, a cruel and capricious tyrant, detained him a prisoner at large almost three years.

Soudan, or Dar-Fur, abounds with towns or villages, ill-built, of clay, and none of them very large. Of these it is not worth while to give an account. Its seasons are divided into rainy and dry. The perennial rains, which fall in Dar-Fur from the middle of June till the middle of September in greater or less quantity, but generally both frequent and violent, suddenly invest the face of the country, till then dry and steril, with a delightful verdure. Except where the rocky nature of the soil absolutely impedes vegetation, wood is found in great quantity; nor are the natives assiduous completely to clear the ground, even where it is designed for the cultivation of grain. As soon as the rains begin, the proprietor, and all the assistants that he can collect, go out to the field; and having made holes at about two feet distance from each other, with a kind of hoe, over all the ground he occupies, the *dokn*, a kind of millet, is thrown into them, and covered with the foot, for their husbandry requires not many instruments. The time for sowing the wheat is nearly the same. The *dokn* remains scarcely two months before it is ripe; the wheat about three.

The animals in Soudan, both wild and tame, are the same as in other parts of Africa in the same latitude. Though the Furians breed horses, and purchase very fine ones in Dongola, and from the Arabs to the east of the Nile, the ass is more used for riding; and an Egyptian ass (for the asses of Dar-Fur are diminutive and indocile like those of Britain) fetches from the value of one to that of three slaves. The villages of this country, like those of Abyssinia, are infested with hyenas; and in the unfrequented parts of the country are the elephant, the rhinoceros, the lion, the leopard, and all the other quadrupeds of Africa. The Arabs often eat the flesh of the lion and the leopard; and sometimes they so completely tame those animals, as to carry them loose into the market place. Our author tamed two lions, of which one acquired most of the habits of a dog. He satiated himself twice a week with the offal of the butchers, and then commonly slept for several hours successively. When food was given them, they both grew ferocious towards each other, and towards any one who approached them. Except at that time, though both were males, he never saw them disagree, nor shew any sign of ferocity towards the human race. Even lambs passed them unmolested.

Among the birds, the *vulture perenopterus*, or white-headed vulture, is most worthy of notice. It is of surprising strength, and is said by the natives to be very long-lived, *sed fides penes auctores*. "I have lodged (says Mr Browne) a complete charge of large shot, at about 50 yards distance, in the body of this bird: it seemed to have no effect on him, as he flew to a considerable distance, and continued walking afterwards. I then discharged the second barrel, which was loaded with ball: this broke his wing; but on my advancing to seize him, he fought with great fury with the other. There are many thousands of them in the inhabited district. They divide the field with the hyena: what carrion the latter leaves at night, the former come in crowds to feed on in the day. Near the extremity of each wing is a horny substance, not unlike the spur of an old cock. It is strong and sharp, and a formidable instrument of attack. Some fluid exudes from this bird that smells like musk; but from what part of him I am uncertain." The serpents found in Soudan are the same as in Egypt; but the natives have not the art of charming them like the Egyptians. The locust of Arabia is very common, and is frequently roasted and eaten, particularly by the slaves.

In Dar-Fur there seems to be a scarcity of metals; but

Soudan.

but in its neighbourhood to the fouth and weft all kinds are to be found. The copper brought by the merchants from the territories of certain idolatrous tribes bordering on Fur, is of the fineft quality, in colour refembling that of China, and appears to contain a portion of zinc, being of the fame pale hue. Iron is found in abundance; but they have not yet learned the art of converting it into fteel. Silver, lead, and tin, our author never heard mentioned in Soudan, but as coming from Egypt; but of gold, in the countries to the eaft and weft, the fupply is abundant. Alabafter, and various kinds of marble, are found within the limits of Fur, as is foffil falt within a certain diftrict; and there is a fufficient fupply of nitre, of which, however, no ufe is made.

The reftraint under which Mr Browne was kept in this inhofpitable country, prevented him from making a full catalogue of its vegetable productions. Of the trees which fhade our forefts or adorn our gardens in Europe, very few exift in Dar-Fur. The characteriftic marks of thofe fpecies which moft abound there, are their fharp thorns, and the folid and unperifhable quality of their fubftance. They feem to be much the fame as thofe which Bruce found in Abyffinia. There is a fmall tree called *enneb*, to the fruit of which they have given the name of grapes. It bears leaves of light green hue; and the fruit, which is of a purple colour, is attached, not in bunches, but fingly to the fmaller branches, and interfperfed among the leaves. The internal ftructure of the fruit is not very unlike the grape, which it alfo refembles in fize: but the pulp is of a red hue, and the tafte is ftrongly aftringent. The water-melon *(cucurbita citrullus)* grows wild over almoft all the cultivable lands, and ripens as the corn is removed. In this ftate it does not attain a large fize. The infide is of a pale hue, and has little flavour. As it ripens, the camels, affes, &c. are turned to feed on it, and it is faid to fatten them. The feeds, as they grow blackifh, are collected to make a kind of tar, *kutran*. Thofe plants of the melon which receive artificial culture grow to a large fize, and are of exquifite flavour. Tobacco is produced in abundance; and our author fpeaks of cochineal as found in Dar-Fur, or fome of the neighbouring countries.

The harveft is conducted in a very fimple manner. The women and flaves of the proprietor are employed to break off the ears with their hands, leaving the ftraw ftanding, which is afterwards applied to buildings and various other ufeful purpofes. They then accumulate them in bafkets, and carry them away on their heads. When thrafhed, which is aukwardly and incompletely performed, they expofe the grain to the fun till it become quite dry; after this a hole in the earth is prepared, the bottom and fides of which are covered with chaff to exclude the vermin. This cavity or magazine is filled with grain, which is then covered with chaff, and afterwards with earth. In this way the maize is preferved tolerably well. In ufing it for food, they grind it, and boil it in the form of polenta, which is eaten either with frefh or four milk, or ftill more frequently with a fauce made of dried meat pounded in a mortar, and boiled with onions, &c. The Furians ufe little butter; with the Egyptians and Arabs it is an article in great requeft. There is alfo another fauce which the poorer people ufe and highly relifh; it is compofed of an herb called *cowel* or *cawel*, of a tafte in part acefcent and in part bitter, and generally difagreeable to ftrangers.

Soudan.

The magiftracy of one, which feems tacitly, if it be not exprefsly favoured by the difpenfation of Mohammed, as in moft other countries profeffing that religion, prevails in Dar-Fur. The monarch indeed can do nothing contrary to the Koran, but he may do more than the laws eftablifhed thereon will authorife; and as there is no council to controul or even to affift him, his power may well be termed defpotic. He fpeaks in public of the foil and its productions as his perfonal property, and of the people as little elfe than his flaves.

His power in the provinces is delegated to officers, who poffefs an authority equally arbitrary. In thofe diftricts, which have always, or for a long time, formed an integral part of the empire, thefe officers are generally called *Meleks*. In fuch as have been lately conquered, or, perhaps more properly, have been annexed to the dominion of the Sultan under certain ftipulations, the chief is fuffered to retain the title of Sultan, yet is tributary to and receives his appointment from the Sultan of Fur.

Defpotic and arbitrary as he is, the Sultan here does not feem wholly inattentive to that important object, agriculture. Neverthelefs, it may be efteemed rather a blind compliance with ancient cuftom, than individual public fpirit, in which has originated a practice adopted by him, in itfelf fufficiently laudable, fince other of his regulations by no means conduce to the fame end. At the beginning of the *Harif*, or wet feafon, which is alfo the moment for fowing the corn, the king goes out with his Melecks and the reft of his train; and while the people are employed in turning up the ground and fowing the feed, he alfo makes feveral holes with his own hand. The fame cuftom, it is faid, obtains in Bornou and other countries in this part of Africa. It calls to the mind a practice of the Egyptian kings mentioned by Herodotus.

The population of Dar-Fur is not large. An army of 2000 men was fpoken of, when Mr Browne was in the country, as a great one; and he does not think that the number of fouls within the empire can much exceed 200,000. The troops of this country are not famed for fkill, courage, or perfeverance. In their campaigns, much reliance is placed on the Arabs who accompany them, and who are properly tributaries rather than fubjects of the fultan. One energy of barbarifm they indeed poffefs in common with other favages, that of being able to endure hunger and thirft; but in this particular they have no advantage over their neighbours. In their perfons the Furians are not remarkable for cleanlinefs. Though obferving as Mahommedans all the fuperftitious formalities of prayer, their hair is rarely combed, or their bodies completely wafhed. The hair of the pubes and axillæ it is ufual to exterminate; but they know not the ufe of foap; fo that with them polifhing the fkin with unguents holds the place of perfect ablutions and real purity. A kind of farinaceous pafte is however prepared, which being applied with butter to the fkin, and rubbed continually till it become dry, not only improves its appearance, but removes from it accidental furdes, and ftill more the effect of continued tranfpiration, which, as there are no baths in the country, is a confideration of fome import-

ance.

Soudan.

ance. The female flaves are dextcrous in the application of it; and to undergo this operation is one of the refinements of African fenfuality.

Nothing refembling current coin is found in Soudan, unlefs it be certain fmall tin rings, the value of which is in fome degree arbitrary. The Auftrian dollars, and other filver coins brought from Egypt, are all fold as ornaments for the women.

The difpofition of the Furians is cheerful; and that gravity and referve which the precepts of Mahommedifm infpire, and the practice of the greater number of its profeffors countenances and even requires, feems by no means as yet to fit eafy on them. A government perfectly defpotic, and not ill adminiftered, as far as relates to the manners of the people, yet forms no adequate reftraint to their violent paffions. Prone to inebriation, but unprovided with materials or ingenuity to prepare any other fermented liquor than *buza*, with this alone their convivial exceffes are committed. But though the Sultan publifhed an ordnance (March 1795), forbidding the ufe of that liquor under pain of death, the plurality, though lefs publicly than before, ftill indulge themfelves in it. A company often fits from funrife to fun-fet, drinking and converfing, till a fingle man fometimes carries off near two gallons of that liquor. The buza has, however, a diuretic and diaphoretic tendency, which precludes any danger from thefe exceffes. In this country dancing is practifed by the men as well as the women, and they often dance promifcuoufly.

The vices of thieving, lying, and cheating, in bargains, with all others nearly or remotely allied to them, as often happen among a people under the fame circumftances, are here almoft univerfal. No property, whether confiderable or trifling, is fafe out of the fight of the owner, nor indeed fcarcely in it, unlefs he be ftronger than the thief. In buying and felling, the parent glories in deceiving the fon, and the fon the parent; and God and the Prophet are hourly invocated, to give colour to the moft palpable frauds and falfehoods.

The privilege of polygamy, which, as is well known, belongs to their religion, the people of Soudan pufh to the extreme. By their law, they are allowed four free women, and as many flaves as they can maintain; but the Furians take both free women and flaves without limitation. The Sultan has more than a hundred free women, and many of the Meleks have from twenty to thirty. In their indulgence with women, they pay little regard to reftraint or decency. The form of the houfes fecures no great fecrecy to what is carried on within them; yet even the concealment which is thus offered is not always fought. The fhade of a tree, or long grafs, is the fole temple required for the facrifices to the Cyprian goddefs. In the courfe of licentious indulgence, father and daughter, fon and mother, are fometimes mingled; and the relations of brother and fifter are exchanged for clofer intercourfe.

Previoufly to the eftablifhment of Iflamifm * and kingfhip, the people of Fur feem to have formed wandering tribes; in which ftate many of the neighbouring nations to this day remain. In their perfons they differ from the negroes of the coaft of Guinea. Their hair is generally fhort and woolly, though fome are feen with it of the length of eight or ten inches, which they efteem a beauty. Their complexion is for the moft part perfectly black. The Arabs, who are numerous within the empire, retain their diftinction of feature, colour, and language. They moft commonly intermarry with each other. The flaves, which are brought from the country they call *Fertit* (land of idolaters), perfectly refemble thofe of Guinea, and their language is peculiar to themfelves.

* About a century and a half ago.

Soudan, Souffriere.

The revenues of the crown confift of a duty on all merchandife imported, which, in many inftances, amounts to near a tenth; of a tax on all flaves exported to Egypt; of all forfeitures for mifdemeanors; of a tenth on all merchandife, efpecially flaves, brought from every quarter but Egypt, and when flaves are procured by force, this tenth is raifed to a fifth; of a tribute paid by the Arabs, who breed oxen, horfes, camels, fheep; of a certain quantity of corn paid annually by every village; befides many valuable prefents, which muft be paid by the principal people, both at ftated times and on particular occafions. Add to all this, that the king is chief merchant in the country; and not only difpatches with every caravan to Egypt a great quantity of his own merchandife, but alfo employs his flaves and dependents to trade with the goods of Egypt on his own account, in the countries adjacent to Soudan.

The commodities brought by the caravans from Egypt are, 1. Amber beads. 2. Tin, in fmall bars. 3. Coral beads. 4. Cornelian beads. 5. Falfe cornelian beads. 6. Beads of Venice. 7. Agate. 8. Rings, filver and brafs, for the ancles and wrifts. 9. Carpets, fmall. 10. Blue cotton cloths of Egyptian fabric. 11. White cotton ditto. 12. Indian muflins and cottons. 13. Blue and white cloths of Egypt, called *Melayes*. 14. Sword-blades, ftrait (German), from Cairo. 15. Small looking-glaffes. 16. Copper face-pieces, or defenfive armour for the horfes heads. 17. Fire arms. 18. Kohhel for the eyes. 19. Rhea, a kind of mofs from European Turkey, for food and a fcent. 20. *She*, a fpecies of abfynthium, for its odour, and as a remedy: both the laft fell to advantage. 21. Coffee. 22. *Mahleb*, *Krumphille*, *Symbille*, *Sandal*, nutmegs, 23. *Dufr*, the fhell of a kind of fifh in the Red Sea, ufed for a perfume. 24. Silk unwrought. 25. Wire, brafs, and iron. 26. Coarfe glafs beads, made at Jerufalem, called *herfh* and *munjur*. 27. Copper culinary utenfils, for which the demand is fmall. 28. Old copper for melting and reworking. 29. Small red caps of Barbary. 30. Thread linens of Egypt—fmall confumption. 31. Light French cloths, made into benifhes. 32. Silks of Scio, made up. 33. Silk and cotton pieces of Aleppo, Damafcus, &c. 34. Shoes of red leather. 35. Black pepper. 36. Writing paper *(papier des trois lunes)*, a confiderable article. 37. Soap of Syria.

The goods tranfported to Egypt are, 1. Slaves, male and female. 2. Camels. 3. Ivory. 4. Horns of the rhinoceros. 5. Teeth of the hippopotamus. 6. Oftrich feathers. 7. Whips of the hippopotamus's hide. 8. Gum. 9. Pimento. 10. Tamarinds, made into round cakes. 11. Leather facks for water (*ray*) and dry articles (*geraub*). 12. Peroquets in abundance, and fome monkeys and Guinea fowls. 13. Copper, white, in fmall quantity.

SOUFFRIERE, a fmall town, fituated at the bottom of a bay, towards the leeward extremity of the ifland of St Lucia. There is nothing in the town itfelf which could

could have entitled it to notice in this work; but the ground about it is very remarkable. It has been defcribed by different authors; and our readers will probably not be ill pleafed with the following defcription of this wonderful fpot by Dr Rollo.

"Souffriere (fays he) is furrounded by hills covered with trees, the declivities of which, and every part capable of produce, are cultivated, and afford good fugar-cane. This place has its marfhes, but not fo extenfive, or fo much to windward as thofe about Carenage.

"The extremity of the fouth fide of Souffriere Bay runs into two fteep hills of a conical figure, which are nearly perpendicular: they are reckoned the higheft on the ifland, and are known by the name of the *Sugar Loaf Hills*. From their height and ftraitnefs it is impoffible to afcend them: we were told it was once attempted by two negroes, but they never returned. They are covered with trees and fhrubs, and are the fhelter of goats, feveral of which fometimes defcend, and are fhot by the natives.

"After you pafs the hills to windward of Souffriere, a fine clear and level country prefents itfelf. From the back of the Sugar Loaf Hills, and all along the fea-coaft, to the diftance, we fuppofe, of from fifteen to twenty miles, this flat or level extends: it is all cultivated and divided into rich eftates, affording fugar-cane equal to any in our iflands. This beautiful fpot is interfected by many rivers of very clear water, and thefe are conducted by art to the purpofe of fugar making. The rains in this part are lefs frequent than on any other part of the ifland; however, they have often a proportion more than fufficient. The wind here blows from the fea, or nearly fo.

"We cannot finifh this defcription without taking notice of a volcano in the neighbourhood of Souffriere. You pafs over one or two fmall hills to the fouthward of the town, and before any mark of the place is perceived you are fenfible of the fmell of fulphur. The firft thing you difcern is a rivulet of black running water, fending forth ftreams as if nearly boiling. From the profpect of this you foon open on the volcano, which appears in a hollow, furrounded clofe on every fide by hills. There are only two openings; the one we entered, and another almoft oppofite to it on the north fide. In the hollow there are many pits of a black and thick boiling matter, which feems to work with great force. Lava is flowly thrown out; and in the centre of the hollow there is a large mafs of it, forming a kind of hill. This we afcended; but were foon obliged to return from the exceffive heat. The lava is a fulphur mixed with a calcareous earth and fome faline body. We found fmall quantities of alum in a perfect ftate. In the opening, at the north fide of the hollow, there is a rivulet of very good water. On ftirring the bottom, over which this water runs, we were furprifed with feeling it very hot; and on placing a tumbler filled with fome of the water clofe to the bottom of the rivulet, it foon became fo hot as not to be touched. The liquid which runs from the pits is ftrongly impregnated with fulphur, and refembles a good deal the preparation fold in the fhops, known by the name of *aqua fulphurata*, or *gas fulphuris*."

SOUND-BOARD, the principal part of an organ, and that which makes the whole machine play. This found-board, or fummer, is a refervoir into which the wind, drawn in by the bellows, is conducted by a port-vent, and thence diftributed into the pipes placed over the holes of its upper part. The wind enters them by valves, which open by preffing upon the ftops or keys, after drawing the regifters, which prevent the air from going into any of the other pipes befides thofe it is required in.

Sound-Board denotes alfo a thin broad board placed over the head of a public fpeaker, to enlarge and extend or ftrengthen his voice.

Sound-boards, in theatres, are found by experience to be of no fervice; their diftance from the fpeaker being too great to be impreffed with fufficient force. But found-boards immediately over a pulpit have often a good effect, when the cafe is made of a juft thicknefs, and according to certain principles.

Sound-Poft, is a poft placed withinfide of a violin, &c. as a prop between the back and the belly of the inftrument, and nearly under the bridge.

SOWAL, in the language of Bengal, a queftion or requeft.

SPALLANZANI (Lazarus), was born at Scandiano, in the duchy of Modena, on the 10th of January 1729. He was fon of Jean Nicholas Spallanzani, an efteemed jurifconfult, and of Lucia Zugliani. He commenced his ftudies in his own country, and at the age of fifteen years went to Reggio de Modena in order to continue them. The Jefuits, who inftructed him in the belles lettres, and the Dominicans, who heard of his progrefs, were each defirous of attaching him to them; but his paffion for extending his knowledge led him to Bologna, where his relation Laura Baffi, a woman juftly celebrated for her genius, her eloquence, and her fkill in natural philofophy and the mathematics, was one of the moft illuftrious profeffors of the Inftitute and of Italy. Under the direction of this enlightened guide, he learned to prefer the ftudy of Nature to that of her commentators, and to judge of the value of the commentary by its refemblance to the original. He inftantly availed himfelf of the wifdom of that lady's counfels, and was not long before he experienced the happy effects of it. How agreeable it is to fee him in 1765 painting his gratitude for his inftructor, to whom he dedicated a Latin differtation at that time, in which he mentions the applaufes that Laura Baffi received at Modena, when fhe entered the auditory of her pupil, then become profeffor. The tafte of Spallanzani for philofophy was not exclufive; he already thought, like all great men, that the ftudy of antiquity and the belles lettres was requifite to give to ideas that clearnefs, to expreffions that accuracy, and to reafonings that connection, without which the fineft thoughts become barren. He ftudied his own language with care, and perfected himfelf in the Latin tongue; but above all, he attached himfelf to the Greek and the French. Homer, Demofthenes, St Bafil, were his favourite authors. Spallanzani applied himfelf to jurifprudence at the inftance of a father whom he tenderly loved: he was upon the point of receiving the degree of doctor of civil law, when Anthony Vallifneri, profeffor of natural hiftory at Padua, perfuaded him to renounce this vocation, by promifing to obtain the confent of his father, who was fenfibly touched by his fon's devotion to his will, and who thereby left him at liberty to follow his own inclinations. From that moment he gave himfelf up with more ardour than ever to the ſtudy of mathematics, continuing that alſo of the living and dead languages.

Spallanzani was preſently known all over Italy, and his own country was the firſt to do homage to his talents. The univerſity of Reggio, in 1754, choſe him to be profeſſor in logic, metaphyſics, and Greek. He taught there for ten years; and during that period conſecrated all the time he could ſpare from his leſſons to the obſervation of Nature. Now and then an accidental diſcovery would increaſe his paſſion for natural hiſtory, which always augmented by new ſucceſſes. His obſervations upon the animalculæ of infuſions fixed the attention of Haller and of Bonnet; the latter of whom aſſiſted him in his glorious career, and thenceforth diſtinguiſhed him as one of the learned interpreters of Nature.

In 1760 Spallanzani was called to the univerſity of Modena; and although his intereſt would have made him accept the advantageous offers of the univerſity of Coimbra, of Parma, and of Ceſena; yet his patriotiſm and his attachment to his family confined his ſervices to his own country. The ſame conſiderations engaged him to refuſe the propoſitions made him by the academy of Peterſburg ſome years after. He remained at Modena till the year 1768, and he ſaw raiſed by his care a generation of men conſtituting at this time the glory of Italy. Among them may be counted *Venturi*, profeſſor of natural philoſophy at Modena; *Belloni*, biſhop of Carpi; *Luccheſini*, ambaſſador of the late king of Pruſſia; and the poet *Angelo Mazzo* of Parma.

During his reſidence at Modena, Spallanzani publiſhed, in 1765, *Saggio di Oſſervazioni Microſcopiche concernente il Syſtema di Needham e Buffon.* He therein eſtabliſhes the *animality* of what had been called, but not generally aſſented to as, *microſcopic animalculæ*, by the moſt ingenious, and at the ſame time ſolid, experiments. He ſent this work to Bonnet, who formed his opinion of the author accordingly, and who lived to ſee the accompliſhment of the prophecy he drew from it. From that moment the moſt intimate acquaintance was formed between them, and it laſted during their lives, of which it conſtituted the chief happineſs. In the ſame year Spallanzani publiſhed a diſſertation truly original: *De Lapidibus ab Aqua reſilientibus.* In that work he proves, by ſatisfactory experiments, contrary to the commonly received opinion, that the ducks and drakes (as they are called) are not produced by the elaſticity of the water, but by the natural effect of the change of direction which the ſtone experiences in its movement, after the water has been ſtruck by it, and that it has been carried over the bend or hollow of the cup formed by the concuſſion.

In 1768 he prepared the philoſophers for the ſurpriſing diſcoveries he was about to offer them throughout his life, in publiſhing his *Prodromo di un Opera da Imprimerſi ſopra le Riproduzioni Animali.* He therein lays down the plan of a work which he was anxious to get up on this important ſubject; but this ſimple proſpectus contains more real knowledge than all the books which had appeared, becauſe it taught the method that ought to be followed in this dark reſearch, and contained many unexpected facts; ſuch as the pre-exiſtence of tadpoles at the fecundation, in many ſpecies of toads and frogs; the reproduction of the head cut off from ſnails, which he had already communicated to Bonnet in 1766, and which was diſputed for ſome time, in ſpite of the repeated confirmation of this phenemenon by Heriſſant and Lavoiſier. He demonſtrated it again afterwards in the *Memorie della Societa Italiana;* as alſo the renewal of the tail, the limbs, and even the jaws, taken from the aquatic ſalamander. Theſe facts continue to aſtoniſh even at this day, when they are thought of, notwithſtanding every one has had the opportunity of familiariſing himſelf with them: and we hardly know which we ought moſt to admire, the expertneſs of Spallanzani in affording ſuch deciſive proofs, or his boldneſs in ſearching after them, and ſeizing them. We have to regret, that the project of his great undertaking is not realized; but various circumſtances prevented him from giving way to the ſolicitations of his friends for its accompliſhment. Perhaps he deſpaired of throwing upon every part of it all the light which at firſt he thought he might be able; and found it prudent to mature his ideas by new meditations: this may probably have been as powerful a cauſe as that other calls and occupations, perpetually accumulating, ſhould not have allowed him to purſue it as he had intended. He has always laid Nature open to full view; and the thinneſt veil darkened her till he ſucceeded in removing it altogether.

The phyſiology of Haller that Spallanzani ſtudied, fixed his attention upon the circulation of the blood, in which he diſcovered ſeveral remarkable phenomena. He publiſhed, in 1768, a ſmall tract: *Dell' Azione del Cuore ne' Vaſi Sanguigni nuovi Oſſervazioni*, and he reprinted it in 1773, with three new diſſertations, *De' Fenomeni della Circolazione oſſervata nel' Giro univerſali de' Vaſi; De' Fenomeni della Circolazione Languente; De' Moti del Sangue, independente del Azione del Cuore e del Pulſare delle Arterie* This work, but little known, contains a ſeries of obſervations and experiments, of the moſt ingenious and delicate nature, upon a ſubject of which the ſurface only is known. It merits the attention of thoſe who are intereſted in the progreſs of phyſiology.

When the univerſity of Padua was re-eſtabliſhed upon a larger ſcale, the Empreſs Maria Thereſa directed the Count de Firmian to invite him to fill a chair, as profeſſor of natural hiſtory; his great reputation rendered him eligible for this diſtinction, ſolicited by many celebrated men, and he merited it by his ſucceſs, and by the crowd of ſtudents who thronged to his leſſons. Only great men make excellent maſters, becauſe their ideas are the moſt perſpicuous, the moſt extenſive, and beſt connected.

Spallanzani united a vaſt extent of knowledge to a fine genius; a method ſimple, but rigorous in its nature; and he connected what he knew to principles firmly eſtabliſhed. His ardent love of truth made him diſcuſs, with the utmoſt care, the theories which prevailed; to found their ſolidity, and diſcover their weak ſides. The great art which he had acquired, of interpreting Nature by herſelf, diffuſed ſuch a light over his leſſons, as made every thing perſpicuous that was capable of affording inſtruction. An eloquence at once plain and lively animated his diſcourſe; the purity and elegance of his ſtyle charmed all who heard it: in ſhort, it was known that he always occupied himſelf about the

the means of rendering his lessons useful, which he prepared a year beforehand. They became always new and engaging, by his new observations, and by the enlarged views that his meditations presented to him. The learned persons who attended his lectures were pleased to become his scholars, in order to know better what they already knew, and to learn that which otherwise they would perhaps never have known.

In arriving at the university, Spallanzani took the *Contemplation de la Nature* of Bonnet for the text of his lessons: he filled up the vacancies in it, he unfolded the ideas, and confirmed the theories by his experiments. He believed, with reason, that the book which inspired him with the love of natural history by reading it, was the most proper to give birth to it in the minds of his disciples.

He translated it into Italian, and enriched it with notes; he added a preface to it, wherein he pointed out the subjects of the vegetable and animal economy, which in an especial manner deserved the attention of his pupils; and sometimes pointing out to them the means of succeeding in their researches. It was thus he at first devoted himself to the pleasing employment of instructor of his countrymen, and that he became the model of those who were desirous of instructing usefully. He published the first volume of his translation in 1769, and the second in 1770.

The connection of Spallanzani with Bonnet had an influence upon his genius, which bent to the severe method of the philosopher of Geneva. He prided himself in being his pupil, and he unceasingly meditated upon his admirable writings; and thus it was that he became desirous of seeking in Nature for the proofs of Bonnet's opinion upon the generation of organized bodies, and that this charming subject fixed his attention for a long time.

He published, in 1776, the two first volumes of his *Opuscoli di Fisica Animale e Vegetabile*: they are the explanation of a part of the microscopic observations which had already appeared.

If the art to observe be the most difficult, it is nevertheless the most necessary of all the arts; but it supposes every quality, every talent: and further, though each believes himself more or less consummate therein, yet it is obvious, that only great men have exercised it in a distinguished manner. Genius alone fixes the objects worthy of regard; that alone directs the senses to the obscurities which it is necessary to dissipate; it watches over them to prevent error; it animates them to follow by the scent, as it were, that which they have but a distant view of: it takes off the veil which covers what we are looking after; it supports the patience which waits the moment for gratifying the sight in the midst of obstacles multiplying one upon another: in short, it is genius that concentrates the attention upon an object, which communicates that energy to him for imagining, that sagacity for discovering, that promptness for perceiving, without which we see only one side of truth, when we do not happen to let it escape altogether. But this is not all; for after Nature has been read with precision, it is necessary to interpret her with fidelity; to analyse by the thought the phenomena anatomised by the senses; to consider of the species by observing the individual, and to anticipate the general propositions by considering the unconnected facts. Here prudence and circumspection will not always secure us against error, if an ardent love for the truth does not assay observations and their consequences in its crucible, and thereby reduce every thing to *scoriæ* which is not truth.

Such was Spallanzani in all his researches; such we see him in all his writings. Occupied by the great phenomenon of generation, he examined the opinion of Needham to demonstrate its want of foundation. The latter, not satisfied with the microscopic observations of Spallanzani, which weakened the imagined vegetative force to put the matter in motion, challenged the professor of Reggio to a reperusal of what he had written; but he proved to the other, that we in common practice always see that which has been *well observed*, but that we never again see that which we have been contented with *imagining we saw*.

Spallanzani has received much praise for the politeness with which he carried on this controversy, and for the severe logic with which he demonstrates to Needham the causes of his error; and proves, that the animalculæ of infusions are produced by germs; that there are some of them which defy, like certain eggs and seeds, the most excessive cold, as well as the heat of boiling water. On this occasion, he treats on the influence of cold upon animals, and proves that the lethargic numbness of some, during winter, does not depend upon the impression the blood may receive from it; since a frog, deprived of his blood, becomes lethargic when he is reduced to the same cold state by an immersion in ice, and swims as before when restored to warmth. In the same manner he shews that odours, various liquors, the vacuum, act upon animalculæ as upon other animals; that they are oviparous, viviparous, and hermaphrodite. Thus, in running over these distant regions of Nature with this illustrious traveller, we are always meeting with new facts, profound remarks, precious details, and some curious anecdotes; in short, an universal history of those beings which are the most numerous of the globe, although their existence is scarcely suspected, and whose organization is in many respects different from that of known animals.

The second volume of this work is a new voyage into the most unknown parts: a sublime pencil had already painted it, but the picture was not done after Nature. Spallanzani here gives a history of the spermatic animalculæ, which the eloquent historian above alluded to always confounds with the animalculæ of infusions. We cannot but admire the modest diffidence of this new demonstrator, struggling against his own opinion and the authority of Buffon; and he appears to admit, with repugnance, the results of his multiplied, and in a thousand ways varied, observations, which expose the feebleness of the system of organic moleculæ.

Spallanzani afterwards describes the volvox and the slow-moving animalculæ (*rotifere* and *tardigrade*), those colossuses of the microscopic world, so singular by their figure and organization, but more singular still by their faculty of resuming life, after a total suspence of all the apparent acts of it during many years.

We will not here speak of the experiments of Spallanzani on the death of animals in close vessels, because he took up the subject again, and enlarged and exemplified it by the new lights of chemistry; but this collection

Spallanzani.

lection he concludes with another on the hiftory of vegetable mould growing on the furface of liquors and moift fubftances, the feeds of which he fhews to float in the air; and he remarks, that thefe microfcopic champignons or mufhrooms diftinguifh themfelves from other plants by their tendency to grow in all directions, without conforming to the almoft univerfal law of perpendicularity of ftalk to the ground.

Spallanzani was placed at the head of the univerfity's cabinet of natural hiftory, but he was little more than titular depofitary of a treafure which no longer exifted. He laid the foundations, however, for its renewal, and by his care it is become one of the moft precious and ufeful. He enriched it through his repeated travels by land and fea, in Europe, in Afia, acrofs the Apennines, the Alps, the Krapacks, at the bottom of mines, on the top of volcanoes, at the mouth of craters: fupported by his ardent paffion in the midft of perils, he preferved the *fang froid* of the philofopher to contemplate thefe wonders, and the piercing eye of an obferver to ftudy them. It is thus that he always diftinguifhed the proper objects for improving fcience by favouring inftruction; it is thus that he filled this depofitary with treafures, that all the gold in the world could not have obtained, becaufe gold never fupplies the genius and the difcernment of the enlightened naturalift.

In 1779 Spallanzani ran over Switzerland and the Grifons; he then went to Geneva, where he fpent a month with his friends, who admired him the more in his converfations after having admired him in his writings. He then returned to Pavia, and publifhed, in 1780, two new volumes of his *Differtazione di Fifica Animale e Vegetabile.* He therein reveals the fecrets of the interpretation of two very obfcure phenomena, concerning the vegetable and animal economy.

Some experiments made by Spallanzani upon *digeftion*, for his leffons, engaged him to ftudy this dark operation: he repeated Reaumur's experiments upon the gallinaceous birds; and he obferved that the trituration, which is in this cafe an aid to digeftion, could not, however, be a very powerful means. He faw that the gizzard of thofe birds which pulverife the ftones of fruit to pieces, as if done with needles or other fharp-pointed inftruments, did not digeft the powder fo formed: that it was neceffary it fhould undergo a new operation in the ftomach, before it could become fit chyle for affording the elements of the blood and other humours. He eftablifhed the point, that the digeftion was performed in the ftomach of numerous animals by the powerful action of a juice which diffolves the aliments; and to render his demonftration the more convincing, he had the courage to make feveral experiments on himfelf which might have proved fatal, and had the addrefs to complete his proofs by artificial digeftions, made in glaffes upon the table, by mixing the chewed aliments with the gaftric juice of animals, which he knew how to extract from their ftomachs. But this book, fo original by the multitude of experiments and curious obfervations which it contains, is ftill more worthy of attention by the philofophic fpirit which detected it.

This fubject is one of the moft difficult in phyfiology: the obferver is always compelled to act and to look with darknefs around him; he is obliged to manage the animal with care, to avoid the derangement of his operations; and when he has laborioufly completed his experiments, it is neceffary that he fhould well diftinguifh the confequences, fometimes erroneous, which may be drawn from thofe of obfervation, which never deceive when they are immediate. Spallanzani, in this work, is truly a fine fpectacle; fcrupuloufly analyfing the facts in order to difcover their caufes with certainty; inventing happy refources for furmounting the obftacles which renew themfelves; comparing Nature with his experiments, to judge of them; catching hold in his obfervations of every thing that is effential in them; meafuring their folidity by the augmentation or diminution of fuppofed caufes; drawing the beft founded conclufions, and rejecting the moft plaufible hypothefes; modeftly expofing the errors of thofe who have gone before him, and employing analogy with that wife circumfpection which infpires confidence in an inftrument at once fo dangerous and fo ufeful. But let it be known, Spallanzani had a capacity in particular for difcovering the truth, while the greater part of obfervators fcarcely ever attain it; and then, after having defcribed around them a circuitous trace, he runs upon it by a ftraight line, and poffeffes himfelf of it fo as that it cannot efcape him.

This work put John Hunter out of humour; and he publifhed, in 1785, *Some Obfervations upon Digeftion*, wherein he threw out fome bitter farcafms againft Spallanzani; who took ample revenge by publifhing this work in Italian, and addreffing to *Caldani*, in 1788, *Una Lettera Apologetica in Rifpofta alle Offervazione del Signor Giovanni Hunter*. He expofes, with moderation, but with an irrefiftible logic, the overfights of the Englifh phyfiologift, and points out his errors in a manner which left him no hope of a reply.

The fecond volume treats of the generation of animals and plants. Spallanzani proves, by experiments as fatisfactory as they are furprifing, the pre-exiftence of germs to fecundation; he fhews the exiftence of tadpoles in the females of five different fpecies of frogs, in toads, and in falamanders, before their fecundation: he recounts the fuccefs of fome artificial fecundations upon the tadpoles of thofe five fpecies, and even upon a quadruped. He in the fame manner fhews the feed in the flowers, before the emiffion of their farina; and by a fubtle anatomy of which one can hardly form an idea, he exhibits to the eye in the flower of the *fpartium junceum*, the filiqua, its feeds, with their lobes, and the embryo plant; he purfues them in their expanfion before and after fecundation, and leaves not a doubt but that the feeds and the pericarpia exifted long before the bloffoming of the buds, and confequently a long time before they could have been fecundated. He has repeated thefe obfervations upon various fpecies of plants with the fame refults; in fhort, he has raifed the individuals of plants with female flowers which have borne fecundated feeds, although they were out of the reach even of fufpicion of a communication with the farina of the male flowers. Such is the feries of furprifing phenomena Spallanzani adds to the hiftory of Nature.

According to cuftom, he availed himfelf of the academical vacation of 1781, to make a journey, the object of which was to add to the cabinet of Pavia. He fet out in the month of July for Marfeilles, where he commenced a new hiftory of the fea, which had prefented him with a crowd of novel and curious facts upon

Spallanzani.

on numerous genera of the inhabitants of the ocean. He went likewise to Finale, to Genoa, to Maſſa, and to Carrara, to obſerve the quarries of marble ſo famous with the ſtatuaries; he returned to Spezzia, and thence brought to Pavia an immenſe harveſt of fiſhes, cruſtaceous and teſtaceous, which he depoſited in that cabinet of which his voyages and travels had rendered him ſo worthy to be the guardian. He viſited, in the ſame view, and with the ſame ſucceſs, the coaſts of Iſtria in 1782; the Apennine Mountains in 1783, where he noticed the terrible hurricanes, and the ſurpriſing vapours which rendered that year ſo famous in meteorology. The cabinet of Pavia thus every year ſaw its riches increaſe; and in the ſame proportion it became the object of ſtrangers admiration; but every one admired ſtill more the immenſe labour of Spallanzani, who had collected every part of it.

The Emperor Joſeph knew this when he came into Lombardy: he deſired to have a converſation with Spallanzani; and his majeſty expreſſed his approbation by preſenting him with his medal in gold.

The univerſity of Padua offered to Spallanzani, in 1785, the chair of natural hiſtory, which the death of Anthony Vallifneri had left vacant, promiſing him more conſiderable advantages than thoſe which he enjoyed at Pavia; but the archduke doubled his penſion, and allowed him to accompany to Conſtantinople the Chevalier Zuliani, who had juſt been nominated ambaſſador from the republic of Venice.

He left this city the 21ſt of Auguſt; and during his voyage made ſeveral obſervations upon the marine productions he met with in thoſe climates, as well as upon the meteorological events of every day, among which he had the advantage of beholding a ſpecies of water-ſpout. He touched at ſeveral iſlands in the Archipelago; which he examined, and went aſhore at Troy to viſit the places ſung by the poet whom he preferred to all others; and in treading upon that ground ſo anciently famous, he made ſome geological obſervations truly original. One may judge before hand of the intereſt we ſhall feel in reading the Voyage of Spallanzani, by ſome memoirs which have appeared in the *Memorie della Societa Italiana* upon the water-ſpouts at ſea, the ſtroke of the torpedo, divers marine productions, and the iſland of Cytherea, where he diſcovered a mountain compoſed of various ſpecies of foſſils. Spallanzani arrived at Conſtantinople the 11th of October, and remained there eleven months: he muſt have been greatly out of his element in that country of ignorance and ſuperſtition, if he had not had Nature to ſtudy, and Zuliani to hear him. The phyſical and moral phenomena of this country, quite new to him, fixed his attention; he ſtrayed over the borders of the two ſeas, and climbed up the neighbouring hills; he viſited the iſland of Chalki, where he made known to the Turks a mine of copper, the exiſtence of which they never ſo much as ſuſpected. He went to the Principi iſland, a few miles diſtant from Conſtantinople, where he diſcovered an iron mine equally unthought of by the Turks. He returned to Europe loaded with ſpoils from the Eaſt, compoſed of the creatures of the three kingdoms, peculiar to thoſe regions: after having been uſeful to the Orientals, who were incapable of appreciating his merit, or rather of imagining he could have any, he ſet out on his return for Italy the 16th of Auguſt, 1786.

A voyage by ſea was in every reſpect the moſt ſafe and the moſt commodious; but Spallanzani conſidered the dangers and the inconveniences of the road as nothing when employed in any beneficial purſuit; he braved all the perils of thoſe deſert regions, where there is no police, no ſecurity. When he arrived at Bucharest, he was retained there during nine days by the celebrated and unhappy Mauroceni, hoſpodar of Wallachia. This prince, the friend of ſcience, received him with diſtinction, preſented him with many of the rarities of his country, furniſhed him with horſes for travelling, and alſo gave him an eſcort of thirty troopers throughout the whole extent of his dominions. Spallanzani paſſed by Hermanſtadt in Tranſylvania, and arrived at Vienna the 7th of December, after having viewed the numerous mines of Tranſylvania, of Hungary, and of Germany, which lay in the neighbourhood of his route. Spallanzani remained five days in this capital of Auſtria; he had two very long audiences with the Emperor Joſeph II.; was well received by the higheſt nobility in that metropolis, and viſited by the men of letters. At length arrived at Pavia; the ſtudents came to meet him out of the gates of the city, and accompanied him home, manifeſting their joy all the way by repeated ſhouts. Their great deſire to hear him, drew him almoſt immediately to the auditory, where they forced him to aſcend the chair from which he had been accuſtomed to deliver his lectures to them. Spallanzani, affected by this ſcene, teſtified with eloquence his gratitude and attachment;—friendly wiſhes, cries of joy, clapping of hands, recommenced with more force, and he was obliged to requeſt them to deſiſt, and allow him to take in his houſe that repoſe which was more neceſſary than ever. He had in the courſe of this year above 500 ſtudents.

Spallanzani had acquired glory enough to merit the attacks of envy; but his diſcoveries were too new, too original, too ſolid to be diſputed; envy itſelf was therefore forced to admire him: but that unworthy paſſion, being tired out by the increaſing reputation of that great man, watched the moment to prove that it had not forgotten him. Envy and malignity then called in queſtion his uprightneſs in the adminiſtration of the cabinet of Pavia; the whole of which was the fruit of his own labours: but the darts aimed at his honour only made it ſhine with new luſtre. The integrity of Spallanzani appeared even more pure after the juridical examination of the tribunals. But let us ſtop here; Spallanzani had the fortitude to forget this event which had torn his heart to pieces; the great part of his enemies acknowledged their miſtake, abjured their hatred, and did not deſpair of regaining his friendſhip.

The cabinet of Pavia was always the object of Spallanzani's thoughts; amidſt the numerous rarities which he had placed there, he only ſaw thoſe that were wanting. Struck with its deficiency in volcanic matters, which had neither ſeries nor order, and conſequently excited little intereſt, being a mute article with reſpect to inſtruction (although Italy was the theatre where the fires of volcanoes had for ſo many ages exerciſed their deſolating powers), he took the reſolution, with which his talents, his courage, and his zeal, inſpired him.

Spallanzani.

him. He was defirous to inftruct his pupils, his nation, himfelf, concerning the phenomena fo ftriking, and yet fo little known, and to collect the documents of their hiftory in the places where they have always been the terror of thofe who furrounded them, and where they have been ufelefsly the fubject of the obfervations of the philofopher. He therefore prepared himfelf for this great enterprife by deep ftudies. He fet out for Naples, in the fummer of 1788, and afcended mount Vefuvius; he looked attentively into its crater, examined and made notes in his books, and embarked for the Lipari iflands. He diffected, as it were, the uninhabited volcanoes, with the exactnefs of a naturalift anatomifing a butterfly, and the intrepidity of a warrior defying the moft imminent dangers. It was then that he had the boldnefs to walk over that fulphurous cruft, cleft with chinks, trembling, fmoking, burning, and fometimes treacheroufly covering the hearth of the volcano. He paffed into Sicily, where he climbed up to Etna, and coafted its immenfe crater. His curiofity not being exhaufted, he would collect around him, and have in his mind, all the fingular phenomena that Sicily contained; he examined the ftones and the mountains, and difcovered many new marine animals; he approached Scylla and Charybdis, and in a boat croffed the frothy billows of thofe deadly rocks, celebrated for fo many fhipwrecks, and fo often fung by the poets; but in the very midft of their frightful waves, he difcovered the caufe of their fury (See Scylla, *Suppl.*) It was thus that, at the age of 60, he picked up thofe numberlefs anecdotes which fill his voyages in the two Sicilies; and that he compared the defcription which Homer, Pindar, Virgil, Diodorus Siculus, and Strabo, have given of thefe ever famous places, with that which he made himfelf. In this manner he fhewed the connection of ancient literature with natural hiftory.

We find in the voyages of Spallanzani a new volcanology. He therein teaches the way to meafure the intenfity of the fire of volcanoes, to glance at the caufes, to touch almoft, in the analyfis which he makes of the lava, that particular gas which, refembling a powerful lever, tears from the bowels of the earth, and raifes up to the top of Etna, thofe torrents of ftone in fufion which it difgorges; to furvey the nature of thofe pumice-ftones, which he has fince explained in his artificial pumice-ftones. He concludes this charming work with fome interefting inquiries into the nature of fwallows, their mild difpofitions, rapid flight; fuggefting that an advantage might be drawn from them in the way of aerial poft; their migrations determined by the temperature of the air, and the birth of infects it occafions: in fhort, he difcuffes the famous problem of their remaining benumbed during winter; and proves, that artificial cold, much greater than that ever naturally felt in our climates, does not render thefe birds lethargic. He next fpeaks of a fpecies of owl, hitherto very ill defcribed; and, laftly, of eels and their generation, which is a problem ftill in fome meafure to be folved; but he carries it on by his inquiries to that ftep which alone remains to be made for obtaining a complete folution; or to get over it eafily by a fmall number of obfervations in thofe times and places pointed out, but which the academical occupations of Spallanzani forced him to give up to others.

Spallanzani followed the progrefs of the French chemiftry with much fatisfaction, nor was he long before he adopted it; it was calculated for a juft conception like his, delighting to give an account of every phenomenon he obferved. The folidity of principles in this new doctrine, the precifion in its way of proceeding, the elegance of its interpretation, the generality of its confequences, prefently replaced in his mind the hefitations and the obfcurities of the ancient chemiftry; and his heart anticipated with pleafure the triumphs that it was about to obtain.

In 1791, Spallanzani publifhed a letter addreffed to Profeffor Fortis, upon the Pennet Hydrofcope. He there relates the experiments which he had directed to be made for afcertaining the degree of confidence which might be allowed to the fingular talents of this man; but he ingenuoufly confeffes, that he is not decided upon the reality of the phenomenon.

Spallanzani has often difcovered that which might have been deemed impoffible. In 1795 he made a difcovery of this nature, which he publifhed in his *Lettere fopra il fofpetto d'un nuovo fenfo nei Pippiftrelli*. We therein learn that the bats, if blinded, act in every refpect with the fame precifion as thofe which have their eyes; that they in the fame manner avoid the moft trifling obftacles, and that they know where to fix themfelves on ceafing their flight. Thefe extraordinary experiments were confirmed by feveral natural philofophers, and gave occafion to fufpect a new fenfe in thefe birds, becaufe Spallanzani thought he had evinced by the way of exclufion, that the other fenfes could not fupply the deficiency of that fight which he had deprived them of; but the anatomical details of Profeffor Jurine, upon the organ of hearing in this fingular bird, made him incline afterwards towards the idea, that the fenfe of hearing might in this cafe fupply that of fight, as in all thofe where the bats are in the dark.

Spallanzani concluded his literary career for the public, by a letter addreffed to the celebrated Giobert; *Sopra la piante chiufe ne'vafi dentro l'aqua e l'aria, efpofte a l' immediàta lume folare e a l'ombra.* It is a misfortune for this part of the fcience, that his death has deprived us of the difcoveries he was about to make in it.

Thefe numerous works, printed and applauded, did not however contain all the feries of Spallanzani's labours. He had been occupied a confiderable time upon the phenomena of refpiration; their refemblances and differences in a great number of fpecies of animals; and he was bufily employed in reducing to order his refearches upon this fubject, which will aftonifh by the multitude of unforefeen and unexpected facts. He has left a precious collection of experiments and new obfervations upon animal reproductions, upon fponges, the nature of which he determines, and upon a thoufand interefting phenomena which he knew how to draw out of obfcurity. He had almoft finifhed his voyage to Conftantinople, and had amaffed confiderable materials for a Hiftory of the Sea, when an end was put to his life and his labours.

On the 4th of February 1799, he was feized with a retention of urine, the fame night was unquiet, and in the morning he loft all powers of reafon, which he never recovered but during very fhort intervals. His intimate friends, Tourdes, a French phyfician, and the celebrated Profeffor Scarpa, did every thing which could,

could be expected from genius, experience, and friendship, to save him; but he died the 17th, after having edified those around him by his piety. This lamentable event overwhelmed all his family in sorrow, occasioned the tears to flow from all his friends, filled his disciples with a deep affliction, and excited the regret of a nation proud of having given him birth.

The reader cannot but have perceived in this sketch the strain of panegyric, rather than the calm narrative of impartial biography. It is, in fact, an abridged translation of an *eloge* by a *citizen* philosopher of Geneva, who has adopted the calendar, and probably the principles of republican France. Some abatement therefore will naturally be made by every Briton of the praises bestowed upon the piety of Spallanzani; but after proper allowance of this kind, truth will proclaim him a very great man. Accordingly, France, Germany, England, all were eager to avail themselves of his works by means of translations. He was admitted into the academies and learned societies of London, Stockholm, Gottingen, Holland, Lyons, Bologna, Turin, Padua, Mantua, and Geneva. He was a correspondent of the academy of sciences of Paris and of Montpelier: and received from the great Frederic himself the diploma of member of the academy of Berlin.

SPECIES, in algebra, are the letters, symbols, marks, or characters, which represent the quantities in any operation or equation.

Species, in optics, the image painted on the retina by the rays of light reflected from the several points of the surface of an object, received in by the pupil, and collected in their passage through the crystalline, &c.

SPECTACLES (See *Encycl.*) are certainly the most valuable of all optical instruments, thougb there is not the same science and mechanical ingenuity displayed in the making of them as in the construction of microscopes and telescopes. A man, especially if accustomed to spend his time among books, would be much to be pitied, when his sight begins to fail, could he not, in a great measure, restore it by the aid of spectacles; but there are some men whose sight cannot be aided by the use either of convex or concave glasses. The following method adopted by one of those to aid his sight is certainly worthy of notice:

When about sixty years of age, this man had almost entirely lost his sight, seeing nothing but a kind of thick mist, while little black specks which appeared to float in the air. He knew not any of his friends, he could not even distinguish a man from a woman, nor could he walk in the streets without being led. Glasses were of no use to him; the best print, seen through the best spectacles, seemed to him like a daubed paper. Wearied with this melancholy state, he thought of the following expedient.

He procured some spectacles with very large rings; and, taking out the glasses, substituted in each circle a conic tube of black Spanish copper. Looking through the large end of the cone he could read the smallest print placed at its other extremity. These tubes were of different lengths, and the openings at the end were also of different sizes; the smaller the aperture the better could he distinguish the smallest letters; the larger the aperture the more words or lines it commanded; and consequently the less occasion was there for moving the head and the hand in reading. Sometimes he used one eye, sometimes the other, alternately relieving each, for the rays of the two eys could not unite upon the same object when thus separated by two opaque tubes. The thinner these tubes, the less troublesome are they. They must be totally blackened within so as to prevent all shining, and they should be made to lengthen or contract, and enlarge or reduce the aperture at pleasure.

When he placed convex glasses in these tubes, the letters indeed appeared larger, but not so clear and distinct as through the empty tube: he also found the tubes more convenient when not fixed in the spectacle rings; for when they hung loosely they could be raised or lowered with the hand, and one or both might be used as occasion required. It is almost needless to add, that the material of the tubes is of no importance, and that they may be made of iron or tin as well as of copper, provided the insides of them be sufficiently blackened. See *La Nouvelle Bigarure* for February 1754, or *Monthly Magazine* for April 1799.

SPECTRE of the Broken, a curious phenomenon observed on the summit of the *Broken*, one of the Harz mountains in Hanover. We have the following account of it by M. Haue. "After having been here (says he) for the thirtieth time, and having procured information respecting the abovementioned atmospheric phenomenon, I was at length, on the 23d of May 1797, so fortunate as to have the pleasure of seeing it; and perhaps my description may afford satisfaction to others who visit the Broken through curiosity. The sun rose about four o'clock, and, the atmosphere being quite serene towards the east, his rays could pass without any obstruction over the Heinrichshöhe. In the south-west, however, towards Achtermannshöhe, a brisk west wind carried before it thin transparent vapours, which were not yet condensed into thick heavy clouds.

"About a quarter past four I went towards the inn, and looked round to see whether the atmosphere would permit me to have a free prospect to the south-west; when I observed, at a very great distance towards Achtermannshöhe, a human figure of a monstrous size. A violent gust of wind having almost carried away my hat, I clapped my hand to it by moving my arm towards my head, and the colossal figure did the same.

"The pleasure which I felt on this discovery can hardly be described; for I had already walked many a weary step in the hopes of seeing this shadowy image, without being able to gratify my curiosity. I immediately made another movement by bending my body, and the colossal figure before me repeated it. I was desirous of doing the same thing once more—but my colossus had vanished. I remained in the same position, waiting to see whether it would return; and in a few minutes it again made its appearance on the Achtermannshöhe. I paid my respects to it a second time, and it did the same to me. I then called the landlord of the Broken; and having both taken the same position which I had taken alone, we looked towards the Achtermannshöhe, but saw nothing. We had not, however, stood long, when two such colossal figures were formed over the above eminence, which repeated our compliments by bending their bodies as we did; after which they vanished. We retained our position; kept our eyes fixed on the same spot, and in a little the two figures again stood before us, and were joined by a third. Every movement that we made by bending our bodies these figures imitated—but with this difference, that the phenomenon was sometimes weak and faint, sometimes strong and well defined. Having thus had an opportunity of discovering the whole secret of this phenomenon, I can give the following information to such of my readers as may be desirous of seeing it themselves. When the rising sun, and according to analogy the case will be the same at the setting sun, throws his rays over the Broken upon the body of a man standing opposite to fine light clouds floating around or hovering past him, he needs only fix his eyes stedfastly upon them, and, in all probability, he will see the singular spectacle of his own shadow extending to the length of five or six hundred feet, at the distance of about two miles before him."

If our memory does not deceive us, there is in one of the volumes of the *Manchester Transactions* an account of a similar phenomenon observed by Dr Ferrier, on a hill somewhere in England.

SPECULUM for reflecting telescopes. Under this title (*Encycl.*) we have given the composition of the mixt metal of which it has been found by experience that the best speculums are made; we have likewise given, under the same title, some directions for casting speculums: but owing to a circumstance in which the public can take no interest, we neglected to give directions for grinding and polishing them, and omitted some other circumstances, which, though not so important as these, are certainly worthy of notice. These omissions it is the object of this article to supply.

When the metal is taken out of the flasks (See n° 3. of the article referred to), which it should be as soon as it has become solid, and while it is yet red-hot, care must be taken to keep the face downwards to prevent it from sinking. Holding it in that position by the git, force out the sand from the hole in the middle of the mirror with a piece of wood or iron, and place the speculum in an iron pot, with a large quantity of hot ashes or small coals, so as to bury the speculum in them a sufficient depth. If the sand is not forced out of the hole in the manner above directed, the metal, by sinking as it cools, will embrace the sand in the middle of the speculum so tight, as to cause it to crack before it becomes entirely cold. And if the metal is not taken out of the sand, and put in a pot with hot ashes or coals to anneal it, the moisture from the sand will always break the metal. Let the speculum remain in the ashes till the whole is become quite cold. The git may be easily taken off by marking it round with a common fine half round file, and giving it then a gentle blow. The metal is then to be rough ground and figured.

It may be proper, however, before we proceed to describe that process, to give an account of another composition for the speculum of a reflecting telescope, which has been employed with great success, by Rochon director of the marine observatory at Brest. Of this composition the principal ingredient is platinum; which, in grains, must be purified in a strong fire by means of nitre and the salt of glass, or that flux which in the English glass-houses is called by the workmen *sandifer*. To the platinum, when purified, add the eighth part of the metal employed in the composition of common specula; for tin without red copper would not produce a good effect. This mixture is then to be exposed to the most violent heat, which must be still excited by the oxygen gas that disengages itself from nitre when thrown into the fire. One melting would be insufficient: five or six are requisite to bring the mixture to perfection. It is necessary that the metal should be in a state of complete fusion at the moment when it is poured into the mould. By this process I have been enabled (says our author) to construct a telescope with platinum, which magnifies the diameters of objects five hundred times, with a degree of clearness and distinctness requisite for the nicest observations. The large speculum of platinum weighs fourteen pounds: it is eight inches in diameter, and its focus is six feet. Though the high price of platinum will, in all probability, for ever prevent it from coming into general use for the speculums of telescopes, we thought it proper to notice this discovery, and shall now proceed to the grinding of the speculum.

For the accomplishing of this object, a very complicated process is recommended in Smith's Optics, and one not much more simpler by Mr Mudge in the 67th volume of the *Philosophical Transactions*; but according to Mr Edwards, whose speculums are confessedly the best, neither of these is necessary. Besides a common grindstone, all the tools that he made use of are a rough grinder, which serves also as a polisher, and a bed of hones. When the speculum was cold, he ground its surface bright on a common grindstone, previously brought to the form of the gage; and then took it to the rough grinder.

This tool is composed of a mixture of lead and tin, or of pewter, and is made of an elliptical form, of such dimensions, that the shortest diameter of the ellipse is equal to the diameter of the mirror or speculum, and the longest diameter is to the shortest in the proportion of ten to nine. This rough grinder may be fixed upon a block of wood, in order to raise it higher from the bench; and as the metal is ground upon it with fine emery, Mr Mudge, with whom, in this particular, Mr Edwards agrees, directs a hole or pit to be made in the middle of it as a lodgement for the emery, and deep grooves to be cut out across its surface with a graver for the same purpose. By means of a handle, fixed on the back of the metal with soft cement, the speculum can be whirled round upon this grinder so rapidly, that a common labourer has been known to give a piece of metal, four inches in diameter, so good a face and figure as to fit it for the hones in the space of two hours. The emery, however fine, will break up the metal very much; but that is remedied by the subsequent processes of honing and polishing.

When the metal is brought to a true figure, it must be taken to a convex tool, formed of some stones from a place called Edgedon in Shropshire, situated between Ludlow and Bishop's castle. The common blue hones, used by many opticians for this purpose, will scarcely touch the metal of Mr Edwards's speculums; but where they must be employed for want of the others, as little water should be used as possible when the metal is put upon them; because it is found by experience that they cut better when but barely wet, than when drenched with water. The stones, however, from Edgedon are greatly preferable; for they cut the metal more easily, and having a very fine grain, they bring it to a smooth face. These stones are directed by Mr Mudge to be cemented in small pieces upon a thick round piece of marble,

marble, or of metal made of tin and lead like the former compofitions, in fuch a manner, that the lines between the ftones may run ftraight from one fide to the other; fo that placing the teeth of a very fine faw in each of thefe divifions, they may be cleared from one end to the other of the cement which rifes between the ftones. As foon as the hones are cemented down, this tool muft be fixed in the lathe, and turned as exactly true to the gage as poffible. It fhould be of a circular figure, and but very little larger than the metal intended to be figured upon it. If it be made confiderably larger, it will grind the metal into a larger fphere and a bad figure; and if it be made exactly of the fame fize, it will work the metal indeed into a figure truly fpherical, but will be apt to fhorten its focus, unlefs the metal and tool be worked alternately upwards. On thefe accounts, Mr Edwards recommends it to be made about one twentieth part longer in diameter than the fpeculum, becaufe he has found that it does not then alter its focus; and he earneftly diffuades the ufe of much water on the hone pavement at the time of ufing it, otherwife, he fays, that the metal in different parts of it will be of different degrees of brightnefs.

When the metal is brought to a very fine face and figure by the bed of ftones, it is ready to receive a polifh, which is given to it by the elliptical rough grinder covered with pitch. With refpect to the confiftency of this pitch, Mr Mudge and Mr Edwards give very different directions. Whilft the former fays that it fhould be neither too hard nor too foft, the latter affirms that the harder the pitch is, the better figure it will give to the metal. Pitch may be eafily made of a fufficient hardnefs by adding a proper quantity of rofin; and when it is hardened in this way, it is not fo brittle as pitch alone, which is hardened by boiling. Mr Edwards advifes to make the mixture juft fo hard as to receive, when cold, an impreffion from a moderate preffure of the nail of one's finger. When the elliptical tool is to be covered with this mixture, it muft be made pretty warm, and in that ftate have the mixture poured upon it when beginning to cool in the crucible. Our author recommends this coating to be made everywhere of about the thicknefs of half-a-crown; and to give it the proper form, it muft, when fomewhat cool, be preffed upon the face of the mirror, which has firft been dipped in cold water, or covered over with very fine writing paper. If it be not found to have taken the exact figure from the firft preffure, the furface of the pitch muft be gently warmed, and the operation repeated as before. All the fuperfluous pitch is now to be taken away from the edge of the polifher with a penknife, and a hole to be made in the middle, accurately round, with a conical piece of wood. This hole fhould go quite through the tool, and fhould be made of the fame fize, or fomewhat lefs than the hole in the middle of the fpeculum. Mr Edwards fays, that he has always found that fmall mirrors, though without any hole in the middle, polifh much better, and take a more correct figure, for the polifher's having a hole in the middle of it.

The polifher being thus formed, it muft be very gently warmed at the fire, and divided into feveral fquares by the edge of a knife. Thefe, by receiving the fmall portion of metal that works off in polifhing, will caufe the figure of the fpeculum to be more correct than if no fuch fquares had been made. Mr Mudge directs the polifher to be ftrewed over with very fine *putty*; but Mr Edwards prefers Colcothar of vitriol. (See that article, *Encycl.*) Putty (fays he) gives metals a white luftre, or, as workmen call it, a filver hue; but good colcothar of vitriol will polifh with a very fine and high black luftre, fo as to give the metal finifhed with it the complection of polifhed fteel. To know if the colcothar of vitriol is good, put fome of it into your mouth, and if you find it diffolves away it is good; but if you find it hard, and crunch between your teeth, then it is bad, and not well burned. Good colcothar of vitriol is of a deep red, or of a deep purple colour; and is foft and oily when rubbed between the fingers; bad colcothar of vitriol is of a light red colour, and feels harfh and gritty. The colcothar of vitriol fhould be levigated between two furfaces of polifhed fteel, and wrought with a little water; when it is worked dry, you may add a little more water, to carry it lower down to what degree you pleafe. When the colcothar of vitriol has been wrought dry three or four times, it will acquire a black colour, and will be low enough, or fufficiently fine, to give an exquifite luftre. This levigated colcothar of vitriol muft be put into a fmall phial, and kept with fome water upon it. When it is to be ufed, every part of the pitch-polifher muft be firft brufhed over with a fine camel's hair brufh, which has been dipped in pure water, and rubbed gently over a piece of dry clean foap. The wafhed colcothar of vitriol is then to be put upon the polifher; and Mr Edwards directs a large quantity of it to be put on at once, fo as to faturate the pitch, and form a fine coating. If a fecond or third application of this powder be found neceffary, it muft be ufed very fparingly, or the polifh will be deftroyed which has been already attained. When the metal is nearly polifhed, there will always appear fome black mud upon its furface, as well as upon the tool. Part of this muft be wiped away with fome very foft wafh leather: but if the whole of it be taken away, the polifhing will not be fo well completed.

With refpect to the *parabolic figure* to be given to the mirror, Mr Edwards affures us, that a very little experience in thefe matters will enable any one to give it with certainty, by polifhing the fpeculum in the common manner, only with crofs ftrokes in every direction, upon an elliptical tool of the proper dimenfions.

SPINDLE, in geometry, a folid body generated by the revolution of fome curve line about its bafe or double ordinate; in oppofition to a conoid, which is generated by the rotation of the curve about its axis or abfcifs, perpendicular to its ordinate. The fpindle is denominated circular, elliptic, hyperbolic, or parabolic, &c. according to the figure of its generating curve.

Spindle, in mechanics, fometimes denotes the axis of a wheel, or roller, &c. and its ends are the pivots.

SPINNING machine. The ancient Greeks were not, like the modern philofophers, unwilling to acknowledge their obligations to Providence for all the comfort and enjoyments of life, nor felt pride in deriving every thing from their own talents. They were even difpofed to think that thofe very talents were infpired. Their firft inftructors, the poets, gave to Apollo the honour of that power of invention and imagination by which they inftructed and charmed their admiring hearers. The prophetefs dictated her oracles, the

Spinning-Machine.

the poet sung his enraptured strain only when inspired. The happy thought of twining a thread, and working it into a blanket, when viewed by that ingenious and acutely sensible people in all its importance, as the protector of the human race from the severity of the weather, seemed a present from heaven, as the inspiration of a divinity; and the distaff and the loom were Minerva's first title to a seat among the great gods on Olympus.

We are much inclined to be of the same opinion. When we observe, that in all the countries which have been discovered by the navigators of the three last centuries, the distaff and spindle, and the needle, have been found, we own ourselves much disposed to think that they are the results of instinct. Our instincts are not all simple and blind, like that which directs the new-born animal to the breast of its mother without knowing why. We have instincts of intellect as well as of appetite; and the logic of common conversation is an example of many such. We doubt not but that the noble-minded inhabitants of Pelew would have worshipped as a divinity an English maiden with her spinning wheel and fly. Surely he who should carry them this homely but ingenious machine, and a potter's wheel, would do them more service than if he taught them all the science of a Newton, with all the philosophy of the 18th century into the bargain. We do not know, except perhaps the steam engine, any mechanical invention that has made such amazing addition to the activity and industry and opulence of this highly favoured island, as the invention of Mr Arkwright for spinning by water, where dead matter is made to perform all that the nicest finger can do when directed by the never-ceasing attention of the intelligent eye. Minerva has the undisputed honours of the distaff and spindle. We know not to what benefactor we owe the fly-wheel. Mr Arkwright has the honour of combining them both, and inspiring them with his own spirit: for we may truly say of the contrivance which pervades the wonderful machinery of a cotton mill,

Totosque infusa per artus
Mens agitat molem et magno se corpore miscet.

To give an intelligible and accurate description of a cotton mill would be abundant employment for a volume. Our limits admit of nothing like this; but as we are certain that many of our readers have viewed a cotton mill with wonder, but not with intelligence, nor with leisure to trace the steps by which the wool from the bag ultimately assumes the form of a very fine thread. Bewildered by such a complication of machinery, all in rapid motion, very few, we imagine, are able to recollect with distinctness and intelligence the essential part of the process by which the form of the cotton is so wonderfully changed. Such readers will not think a page or two misemployed, if they are thereby able to understand this particular, to which all the rest of the process is subservient.

We pass over the operation of carding, by which all the clots and inequalities of the cotton wool are removed, and the whole is reduced to an uniform thin fleece, about 20 inches broad. This is gradually detached from the finishing card, and, if allowed to hang down from it, would pile up on the floor as long as the mill continues to work; but it is guided off from the card, very tenderly, in a horizontal direction, by laying its detached end over a roller, which is slowly turned round by the machine. Another roller lies above the fleece, pressing it down by its weight. By this pressure, a gentle hold is taken of the fleece, and therefore the slow motion of the rollers draws it gently from the card at the same rate as it is disengaged by the comb; but between the card and the rollers a set of smooth pins are placed in two rows, leading from the card to the rollers, and gradually approaching each other as we approach the rollers. By these pins the broad fleece is hemmed in on both sides, and gradually contracted to a thick roll: and in this state passes between the rollers, and is compressed into a pretty firm flat riband about two inches broad, which falls off from the rollers, and piles up in deep tinplate cans set below to receive it.

It is upon this stripe or riband of cotton wool that the operation of spinning begins. The general effect of the spinning process is to draw out this massive roll, and to twist it as it is drawn out. But this is not to be done by the fingers, pulling out as many cotton fibres at once as are necessary for composing a thread of the intended fineness, and continuing this manipulation regularly across the whole end of the riband, and thus, as it were, nibbling the whole of it away. The fingers must be directed, for this purpose, by an attentive eye. But in performing this by machinery, the whole riband must be drawn out together, and twisted as it is drawn. This requires great art, and very delicate management. It cannot be done at once; that is, the cotton roll cannot first be stretched or drawn out to the length that is ultimately produced from a tenth of an inch of the roll, and then be twisted. There is not cohesion enough for this purpose; we should only break off a bit of the roll, and could make no farther use of it. The fibres of cotton are very little implicated among each other in the roll, because the operation of carding has laid them almost parallel in the roll; and though compressed a little by its contraction from a fleece of 20 inches to a riband of only 2, and afterwards compressed between the discharging rollers of the carding machine, yet they cohere so slightly, that a few fibres may be drawn out without bringing many others along with them. For these reasons, the whole thickness and breadth of two or three inches of the riband is stretched to a very minute quantity, and then a very slight degree of twist is given it, viz. about three turns in the inch; so that it shall now compose an extremely soft and spongy cylinder, which cannot be called a thread or cord, because it has scarcely any firmness, and is merely rounder and much slenderer than before, being stretched to about thrice its former length. It is now called slab, or roove.

Although it be still extremely tender, and will not carry a weight of two ounces, it is much more cohesive than before, because the twist given to it makes all the longitudinal fibres bind each other together, and compress those which lie athwart; therefore it will require more force to pull a fibre from among the rest, but still not nearly enough to break it. In drawing out a single fibre, others are drawn out along with it; and if we take hold of the whole assemblage, in two places, about an inch or two inches asunder, we shall find that we may draw it to near twice its length without any risk

riſk of its ſeparating in any intermediate part, or becoming much ſmaller in one part than another. It ſeems to yield equably over all.

Such is the ſtate of the ſlab or roove of the firſt formation. It is uſually called the *preparation*; and the operation of ſpinning is conſidered as not yet begun. This preparation is the moſt tedious, and requires more attendance and hand labour than any ſubſequent part of the proceſs. For the ſtripes or ribands from which it is made are ſo light and bulky, that a few yards only can be piled up in the cans ſet to receive them. A perſon muſt therefore attend each thread of ſlab, to join freſh ſtripes as they are expended. It is alſo the moſt important in the manufacture; for as every inch of the ſlab meets with preciſely the ſame drawing and the ſame twiſting in the ſubſequent parts of the proceſs, therefore every inequality and fault in the ſlab (indeed in the fleece as it quits the finiſhing card) will continue through the whole manufacture. The ſpinning of cotton yarn now divides into two branches. The firſt, performed by what are called *jennies*, perfectly reſembles the ancient ſpinning with the diſtaff and ſpindle; the other, called *ſpinning of twiſt*, is an imitation of the ſpinning with the fly-wheel. They differ in the ſame manner as the ſpinning with the old wool or cotton-wheel differs from the ſpinning with the flax-wheel. Mr Arkwright's chief invention, the ſubſtitution of machinery for the immediate work of the human finger, is ſeen only in the manufacture of twiſt. We ſhall therefore confine our attention to this.

The reſt of the proceſs is little more than a repetition of that gone through in making the firſt ſlab or roove. It is formed on bobins. Theſe are ſet on the back part of the drawing frame; and the end of the ſlab is brought forwards toward the attending workman. As it comes forward, it is ſtretched or drawn to about $\frac{4}{5}$ of its former length, or lengthened $\frac{1}{5}$; and is then twiſted about twice as much as before, and in this ſtate wound up on another bobin. In ſome mills two rooves, after having been properly drawn, are brought together through one hole, and twiſted into one; but we believe that, in the greater number of mills, this is deferred to the ſecond drawing. It is only after the firſt drawing that the produce of the operation gets the name of *ſlab*; before this it is called *preparation*, or *roove*, or by ſome other name. The ſlab is ſtill a very feeble, ſoft, and delicate yarn, and will not carry much more weight than it did before in the form of roove. The perfection of the ultimate thread or yarn depends on this extreme ſoftneſs; for it is this only which makes it ſuſceptible of an equable ſtretching; all the fibres yielding and ſeparating alike.

The next operation is the *ſecond drawing*, which no way differs from the firſt, except in the different proportions of the lengthening, and the proportion between the lengthening and the ſubſequent twiſt. On theſe points we cannot give any very diſtinct information. It is different in different mills, and with different ſpecies of cotton wool, as may be eaſily imagined. The immediate mechaniſm or manipulation muſt be ſkilfully accommodated to the nature of that friction which the fibres of cotton exert on each other, enabling one of them to pull others along with it. This is greatly aided by the contorted curled form of a cotton fibre, and a conſiderable degree of elaſticity which it poſſeſſes. In this reſpect it greatly reſembles woollen fibres, and differs exceedingly from thoſe of flax: and it is for this reaſon that it is ſcarcely poſſible to ſpin flax in this way: its fibres become lank, and take any ſhape by the ſlighteſt compreſſion, eſpecially when damp in the ſlighteſt degree. But beſides this, the ſurface of a cotton fibre has a harſhneſs or roughneſs, which greatly augments their mutual friction. This is probably the reaſon why it is ſo unfit for tents and other dreſſings for wounds, and is refuſed by the ſurgeon even in the meaneſt hoſpitals. But this harſhneſs and its elaſticity fit it admirably for the manufacture of yarn. Even the ſhortneſs of the fibre is favourable: and the manufacture would hardly be poſſible if the fibre were thrice as long as it generally is. If it be juſt ſo long that in the finiſhed thread a fibre will rather break than come out from among the reſt, it is plain that no additional length can make the yarn any ſtronger with the ſame degree of compreſſion by twining. A longer fibre will indeed give the ſame firmneſs of adherence with a ſmaller compreſſion. This would be an advantage in any other yarn; but in cotton yarn the compreſſion is already as ſlight as can be allowed; were it leſs, it would become woolly and rough by the ſmalleſt uſage, and is already too much diſpoſed to teazle out. It can hardly be uſed as ſewing thread. Now ſuppoſe the fibres much longer; ſome of them may chance to be ſtretched along the ſlab through their whole length. If the ſlab is pulled in oppoſite directions, by pinching it at each end of ſuch fibres, it is plain that it will not ſtretch till this fibre be broken or drawn out; and that while it is in its extended ſtate, it is acting on the other fibres in a very unequable manner, according to their poſitions, and renders the whole apt to ſeparate more irregularly. This is one great obſtacle to the ſpinning of flax by ſimilar machinery; and it has hitherto prevented (we believe) the working up of any thing but the *ſhorts* or tow, which is ſeparated from the long fine flax in the operation of hatcheling.

A third, and ſometimes even a fourth, drawing is given to the ſlab formed on the bobins of this ſecond operation. The ſlab produced is now a ſlender, but ſtill extremely ſoft cord, ſuſceptible of conſiderable extenſion, without riſk of ſeparation, and without the ſmalleſt chance of breaking a ſingle fibre in the attempt. In one or more of the preparatory drawings now deſcribed, two, and ſometimes three ſlabs of a former drawing, are united before the twiſt is given them. The practice is different in different mills. It is plain, that unleſs great care be taken to preſerve the ſlab extremely ſoft and compreſſible during the whole proceſs, the ſubſequent drawing becomes more precarious, and we run a riſk of at laſt making a bad and looſe thread inſtead of a uniform and ſimple yarn. Such a thread will have very little lateral connection, and will not bear much handling without ſeparating into ſtrands. The perfection of the yarn depends on having the laſt ſlab as free of all appearance of ſtrands as poſſible.

The laſt operation is the ſpinning this ſlab. This hardly differs from the foregoing drawings in any thing but the twiſt that is given it after the laſt ſtretching in its length. This is much greater than any of the preceding, being intended to give the yarn hardneſs and firmneſs, ſo that it will now break rather than ſtretch any more.

The

The reader, moderately acquainted with mechanics, cannot but perceive that each of the operations now defcribed, by which the roove is changed into the foft flab, and each of thefe into one flenderer and fomewhat firmer, by alternately teazling out and twining the foft cord, is a fubftitute for a fingle pull of the finger and thumb of the fpinfter, which fhe accommodates precifely to the peculiar condition of the lock of wool which fhe touches at the moment. She can follow this thro' all its irregularities; and perhaps no two fucceeding plucks are alike. But when we cannot give this momentary attention to every minute portion, we muft be careful to introduce the roove in a ftate of perfect uniformity; and then every inch being treated in the fame manner, the final refult will be equable—the yarn will be uniform.

We are now to defcribe the mechanifm by which all this is effected. But we do not mean to defcribe a cotton mill; we only mean to defcribe what comes into immediate contact with the thread; and in fo doing, to confine ourfelves to what is neceffary for making the reader perceive its ability to perform the required tafk. We fee many cafes where individuals can apply this knowledge to ufeful purpofes. More than this would, we think, be improper, in a national point of view.

Plate XLIII.

Let ABC reprefent the fection of a roller, whofe pivot D does not turn in a pivot hole, but in the bottom of a long narrow notch DE, cut in an iron ftandard. *a b c* is the fection of another iron roller, whofe pivot *d* is in the fame notches at each end, while the roller itfelf lies or refts on the roller ABC below it. The furfaces of thefe rollers are fluted lengthwife like a column; only the flutings are very fmall and fharp, like deep ftrokes of engraving very clofe together. It is plain, that if the roller ABC be made to turn flowly round its axis by machinery, in the direction ABC (as expreffed by the dart), the roughnefs of the flutings will take hold of the fimilar roughnefs of the upper roller *a b c*, and carry it round alfo in the direction of the dart, while its pivots are engaged in the notches DE, which they cannot quit. If therefore we introduce the end F of the cotton ftring or riband, formed by the carding machine, it will be pulled in by this motion, and will be delivered out on the other fide at H, confiderably compreffed by the weight of the upper roller, which is of iron, and is alfo preffed down by a lever which refts on its pivots, or other proper places, and is loaded with a weight. There is nothing to hinder this motion of the riband thus compreffed between the rollers, and it will therefore be drawn thro' from the cans. The compreffed part at H would hang down, and be piled up on the floor as it is drawn thro'; but it is not permitted to hang down in this manner, but is brought to another pair of fharp fluted iron rollers K and L. Suppofing this pair of rollers to be of the fame diameter, and to turn round in the fame time, and in the fame direction with the rollers ABC, *a b c*; it is plain that K and L drag in the compreffed riband at I, and would deliver it on the other fide at M, ftill more compreffed. But the roller K is made (by the wheelwork) to turn round more fwiftly than ABC. The difference of velocity at the furface of the rollers is, however, very fmall, feldom exceeding one part in 12 or 15. But the confequence of this difference is, that the fkein of cotton HI will be lengthened in the fame proportion; for the upper rollers preffing on the under ones with a confiderable force, their fharp flutings take good hold of the cotton between them; and fince K and L take up the cotton fafter than ABC, and *a b c* deliver it out, it muft either be forcibly pulled through between the firft rollers, or it muft be ftretched a little by the fibres flipping among each other, or it muft break. When the extenfion is fo very moderate as we have juft now faid, the only effect of it is merely to begin to draw the fibres (which at prefent are lying in every poffible direction) into a more favourable pofition for the fubfequent extenfions.

The fibres being thus drawn together into a more favourable pofition, the cotton is introduced between a third pair of rollers O, P, conftructed in the fame way, but fo moved by the wheelwork that the furface of O moves nearly or fully twice as faft as the furface of K. The roller P being alfo well loaded, they take a firm hold of the cotton, and the part between K and O is nearly or fully doubled in its length, and now requires a little twining to make it roundifh, and to confolidate it a little.

It is therefore led floping downwards into a hole or eye in the upper pivot of the firft fly, called a *jack*. This turns round an upright axis or fpindle; the lower end of which has a pulley on it to give it motion by means of a band or belt, which paffes round a drum that is turned by the machinery. This jack is of a very ingenious and complicated conftruction. It is a fubftitute for the fly of the common fpinning wheel. If made precifely in the form of that fly, the thread, being fo very bulky and fpongy, and unable to bear clofe packing on the bobin, would fwag out by the whirling of the fly, and would never coil up. The bobin therefore is made to lie horizontally; and this occafions the complication, by the difficulty of giving it a motion round a horizontal axis, in order to coil up the twifted roove. Mr Arkwright has accomplifhed this in a very ingenious manner; the effential circumftances of which we fhall here briefly defcribe. A is a roller of hard wood, having its furface cut into fharp flutes longitudinally. On the axis, which projects through the fide of the general frame, there is a pulley P, connected by a band with another pulley Q, turning with the horizontal axis QR. This axis is made to turn by a contrivance which is different in every different cotton mill. The fimpleft of all is to place above the pulley C (which is turned by the great band of the machinery, and thus gives motion to the jack) a thin circular difc D, loofe upon the axis, fo as to turn round on it without obftruction. If this difc exceed the pulley in breadth about one-tenth of an inch, the broad belt which turns the pulley will alfo turn it; but as its diameter is greater than that of the pulley, it will turn fomewhat flower, and will therefore have a relative motion with refpect to the axis QR. This can be employed, in order to give that axis a very flow motion, fuch as one turn of it for 20 or 30 of the jack. This we leave to the ingenuity of the reader. The bobin B, on which the roove is to be coiled up, lies on this roller, its pivots paffing through upright flits in the fides of the general frame. It lies on A, and is moved round by it, in the fame manner as the uppermoft of a pair of drawing rollers lies on the under one, and receives motion from it. It is evident that the fluted furfaces of A, by turning flowly round, and carrying

carrying the weight of the bobin, compreffes a little the cotton that is between them; and its flutings, being fharp, take a flight hold of it, and caufe it to turn round alfo, and thus coil up the roove, pulling it in through the hole E in the upper pivot (which refembles the fore pivot or eye of a fpinning wheel fly) in fo gentle a manner as to yield whenever the motion of the bobin is too great for the fpeed with which the cotton fkein is difcharged by the rollers O and P.—*N. B.* The axis QR below, alfo gives motion to a guide within the jack, which leads the roove gradually from one end of the bobin to the other, and back again, fo as to coil it with regularity till the bobin is full. The whole of this internal mechanifm of the jack is commonly fhut up in a tin cylinder. This is particularly neceffary when the whirling motion muft be rapid, as in the fecond and third drawings. If open, the jacks would meet with much refiftance from the air, which would load the mill with a great deal of ufelefs work.

The reader is defired now to return to the beginning of the procefs, and to confider it attentively in its different ftages. We apprehend that the defcription is fufficiently perfpicuous to make him perceive the efficacy of the mechanifm to execute all that is wanted, and prepare a flab that is uniform, foft, and ftill very extenfible; in fhort, fit for undergoing the laft treatment, by which it is made a fine and firm yarn.

As this part of the procefs differs from each of the former, merely by the degree of twift that is given to the yarn, and as this is given by means of a fly not materially different from that of the fpinning wheel for flax, we do not think it at all neceffary to fay any thing more about it.

The intelligent reader is furely fenfible that the yarn produced in this way muft be exceedingly uniform. The uniformity really produced even exceeds all expectation; for even although there be fome fmall inequalities in the carded fleece, yet if thefe are not matted clots, which the card could not equalife, and only confift of a little more thicknefs of cotton in fome places than in others, when fuch a piece of the ftripe comes to the firft roller, it will be rather more ftretched by the fecond, and again by the bobin, after the firft very flight twining. That this may be done with greater certainty, the weights of the firft rooving rollers are made very fmall, fo that the middle part of the fkein can be drawn through, while the outer parts remain faft held.

We are informed that a pound of the fineft Bourbon cotton has been fpun into a yarn extending a few yards beyond 119 miles.

Elater SPRING, in phyfics, denotes a natural faculty, or endeavour, of certain bodies to return to their firft ftate, after having been violently put out of the fame by compreffing, or bending them, or the like. This faculty is ufually called by philofophers *elaftic force*, or *elafticity*.

T. SQUARE, or *Tee Square*, an inftrument ufed in drawing, fo called from its refemblance to the capital letter T.

STAPELIA, a genus of plants belonging to the clafs pentandria, in the Linnæan arrangement, and to the order digynia. The generic characters are the following: The *calyx* is monophyllous, quinquefid, acute, fmall, and permanent. The *corolla* is monopetalous, flat, large, and divided, deeper than the middle, into five parts, with broad, flat, pointed *laciniæ*. The *nectarium* is fmall, ftar-fhaped, flat, quinquefid, with linear *laciniæ*; and embracing with its ragged points the feed-forming parts. Another fmall ftar, which is alfo flat and quinquefid, covers the feminiferous parts with its entire acute *laciniæ*. The *ftamina* are five in number; the *filaments* are erect, flat, and broad; and the *antheræ* are linear, on each fide united to the fide of the filament. The *piftillum* has two *germina*, which are oval and flat on the infide. There are no *ftyles*; and the *ftigmata* are obfolete. The *feed-veffel* confifts of two oblong, awl-fhaped, unilocular and univalved follicles. The *feeds* are numerous, imbricated, compreffed, and crowned with a *pappus* or down.

This fingular tribe of plants is peculiar to the fandy deferts of Africa and Arabia. They are extremely fucculent. From this peculiarity of ftructure, the power of retaining water to fupport and nourifh them, they are enabled to live during the prevalent droughts of thofe arid regions. On this account the ftapelia has been compared to the camel; and we are told that, by a very apt fimilitude, it has been denominated "the *camel* of the vegetable kingdom." We muft confefs ourfelves quite at a lofs to fee the propriety or aptitude of this comparifon. In many parts of the animal and vegetable economy there is doubtlefs a very obvious and ftriking analogy: but this analogy has been often carried too far; much farther than fair experiment and accurate obfervation will in any degree fupport. It is perhaps owing to this inaccuracy in obferving the peculiarity of ftructure and diverfity of functions, that a refemblance is fuppofed to exift, as in the prefent cafe, where in reality there is none. The camel is provided with a bag or fifth ftomach, in addition to the four with which ruminant animals are furnifhed. This fifth ftomach is deftined as a refervoir to contain water; and it is fufficiently capacious to receive a quantity of that neceffary fluid, equal to the wants of the animal, for many days; and this water, as long as it remains in the fifth ftomach, is faid to be perfectly pure and unchanged. The *ftapelia*, and other fucculent plants, have no fuch refervoir. The water is equally, or nearly fo, diffufed through the whole plant. Every veffel and every cell is fully diftended. But befides, this water, whether it be received by the roots, or abforbed from the atmofphere, has probably undergone a complete change, and become, after it has been a fhort time within the plant, a fluid poffeffed of very different qualities.

The peculiar economy in the ftapelia, and other fucculent plants, feems to exift in the abforbent and exhalant fyftems. The power of abforption is as much increafed as the power of the exhalant or perfpiratory veffels is diminifhed. In thefe plants, a fmall quantity of nourifhment is required. There is no folid part to be formed, no large fruit to be produced. They generally have very fmall leaves, often are entirely naked; fo that taking the whole plant, a fmall furface only is expofed to the action of light and heat, and confequently a much fmaller proportion of water is decompofed than in plants which are much branched and furnifhed with leaves.

Two fpecies of ftapelia only were known at the beginning of the century. The unfortunate Forfkål, the companion

Star, Starch.

companion of Niebhur, who was fent out by the king of Denmark to explore the interior of Arabia, and who fell a facrifice to the peftilential difeafes of thofe inhofpitable regions, difcovered two new fpecies. Thunberg, in his *Prodromus*, has mentioned five more. Forty new fpecies have been difcovered by Mr Maffon of Kew Gardens, who was fent out by his prefent Majefty for the purpofe of collecting plants round the Cape of Good Hope. Defcriptions of thefe, with elegant and highly finifhed coloured engravings, have lately been publifhed. They are chiefly natives of the extenfive deferts called *Karro*, on the weftern fide of the Cape.

STAR, in fortification, denotes a fmall fort, having five or more points, or faliant and re-entering angles, flanking one another, and their faces 90 or 100 feet long.

STARCH (fee *Encycl.*) is commonly made of wheat, and the very beft ftarch can poffibly be made of nothing elfe. Wheat, however, is too valuable an article of food to be employed as the material of ftarch, when any thing elfe will anfwer the purpofe; and it has long been known that an inferior kind of ftarch may be made of potatoes. Potatoes, however, are themfelves a valuable article of food: and it is therefore an object of importance to try if ftarch may not be made of fomething ftill lefs ufeful.

On the 8th of March 1796, a patent was granted to Lord William Murray for his difcovery of a method by which ftarch may be extracted from horfe-chefnuts. That method is as follows:

Take the horfe-chefnuts out of the outward green prickly hufks; and then, either by hand, with a knife or other tool, or elfe with a mill adapted for that purpofe, very carefully pare off the brown rind, being particular not to leave the fmalleft fpeck, and to entirely eradicate the fprout or growth. Next take the nuts, and rafp, grate, or grind them fine into water, either by hand, or by a mill adapted for that purpofe. Wafh the pulp, which is thereby formed in this water, as clean as poffible, through a coarfe horfe hair fieve; this again wafh through a finer fieve, and then again through a ftill finer, conftantly adding clean water, to prevent any ftarch from adhering to the pulp. The laft procefs is, to put it with a large quantity of water (about four gallons to a pound of ftarch) through a fine gauze, muflin, or lawn, fo as entirely to clear it of all bran or other impurities. As foon as it fettles, pour off the water; then mix it up with clean water, repeating this operation till it no longer imparts any green, yellow, or other colour to the water. Then drain it off till nearly dry, and fet it to bake, either in the ufual mode of baking ftarch, or elfe fpread out before a brifk fire; being very attentive to ftir it frequently to prevent its horning, that is to fay, turning to a pafte or jelly, which, on being dried, turns hard like horn. The whole procefs fhould be conducted as quickly as poffible.

Mention is here made of a mill which may be employed to grind the horfe-chefnuts; but none is defcribed as proper for that purpofe. Perhaps the following mill, which was invented by M. Beaumé for grinding potatoes, with a view to extract ftarch from them, may anfwer for grinding horfe-chefnuts.

Plate XLII.

He had a grater made of plate iron, in a cylindrical form (fig. 1.) about feven inches in diameter, and about eight inches high: the burs made by ftamping the holes are on the infide. This grater is fupported upon three feet AAA, made of flat iron bars, feven feet high, ftrongly rivetted to the grater; the bottom of each foot is bent horizontally, and has a hole in it which receives a fcrew, as at A, fig. 4. A little below the upper end of the three feet is fixed a crofs piece B (fig. 1. and 4.), divided into three branches, and rivetted to the feet. This crofs piece not only ferves to keep the feet at a proper diftance from each other, and to prevent their bending; but the centre of it having a hole cut in it, ferves to fupport an axis or fpindle of iron, to be prefently defcribed.

The upper end of this cylindrical grater has a diverging border of iron C (fig. 1. 4. and 7.), about ten inches in diameter at the top, and five inches in height.

Within this cylindrical grater is placed a fecond grater (fig. 2. and 3.), in the form of a cone, the point of which is cut off. The latter is made of thick plate iron, and the burs of the holes are on the outfide; it is fixed, with the broad end at the bottom, as in fig. 4. At the upper end of the cone is rivetted a fmall triangle, or crofs piece of iron, confifting of three branches D (fig. 2.), in the middle of which is made a fquare hole, to receive an axis or fpindle; to give more refiftance to this part of the cone, it is ftrengthened by means of a cap of iron E, which is fixed to the grater by means of rivets, and has alfo a fquare hole made in it, to let the axis pafs through.

Fig. 3. reprefents the fame cone feen in front; the bafe F has alfo a crofs piece of three branches, rivetted to a hoop of iron, which is fixed to the inner furface of the cone; the centre of this crofs piece has alfo a fquare hole for the paffage of the axis.

Fig. 5. is a fpindle or axis itfelf; it is a fquare bar of iron about 16 inches long, and more than half an inch thick; round at the bottom, and alfo towards the top, where it fits into the crofs piece I, fig. 7. and B, fig. 1. and 4.; in thefe pieces it turns round, and by them it is kept in its place. It muft be fquare at its upper extremity, that it may have a handle, about nine inches long, fixed to it, by means of which the conical grater is turned round. At G. (fig. 5.), a fmall hole is made through the axis, to receive a pin H, by means of which the conical grater is kept at its proper height within the cylindrical one.

Fig. 6. is a bird's eye view, in which the mill is reprefented placed in an oval tub, like a bathing tub. I is the fore-mentioned triangular iron crofs, fixed with fcrews to the fide of the tub; the centre of it has a round hole, for the axis of the mill to move in when it is ufed.

Fig. 7. reprefents the mill in the oval tub; it is placed at one end of it, that the other end may be left free for any operation to be performed in it which may be neceffary. A part of the tub is cut off, that the infide of it, and the manner of fixing the mill, may be feen. That the bottom of the tub may not be worn by the fcrews which pafs through the feet of the mill, a deal board, about an inch thick, and properly fhaped, is placed under the mill.

When we wifh to make ufe of this mill, it is to be fixed by the feet, in the manner already defcribed; it is alfo fixed at the top, by means of the crofs piece I, fig. 6. and 7. The tub is then to have water poured into

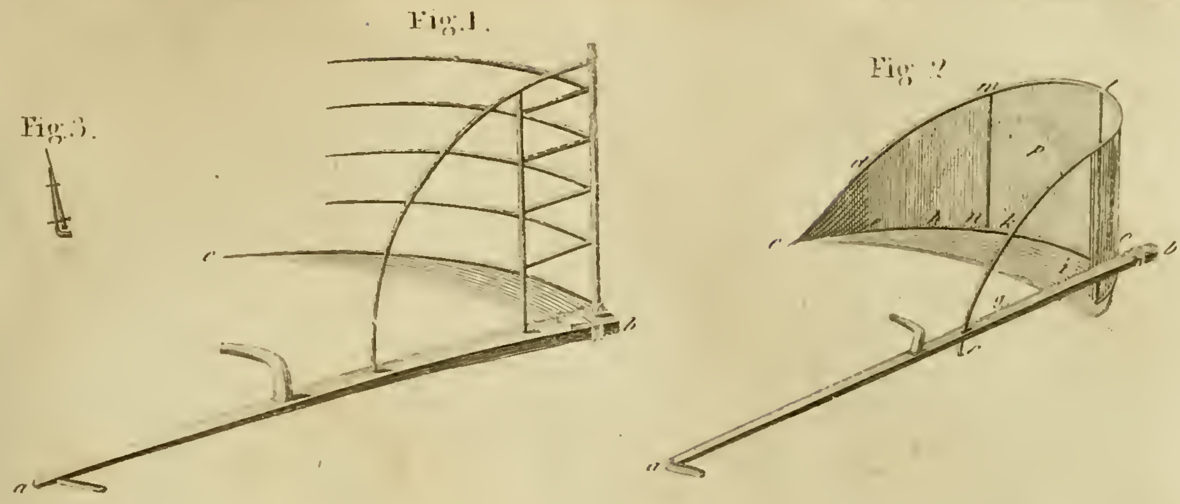
Fig. 1.
Fig. 2.
Fig. 3.
a
b
c
a
b
c

STARCH.

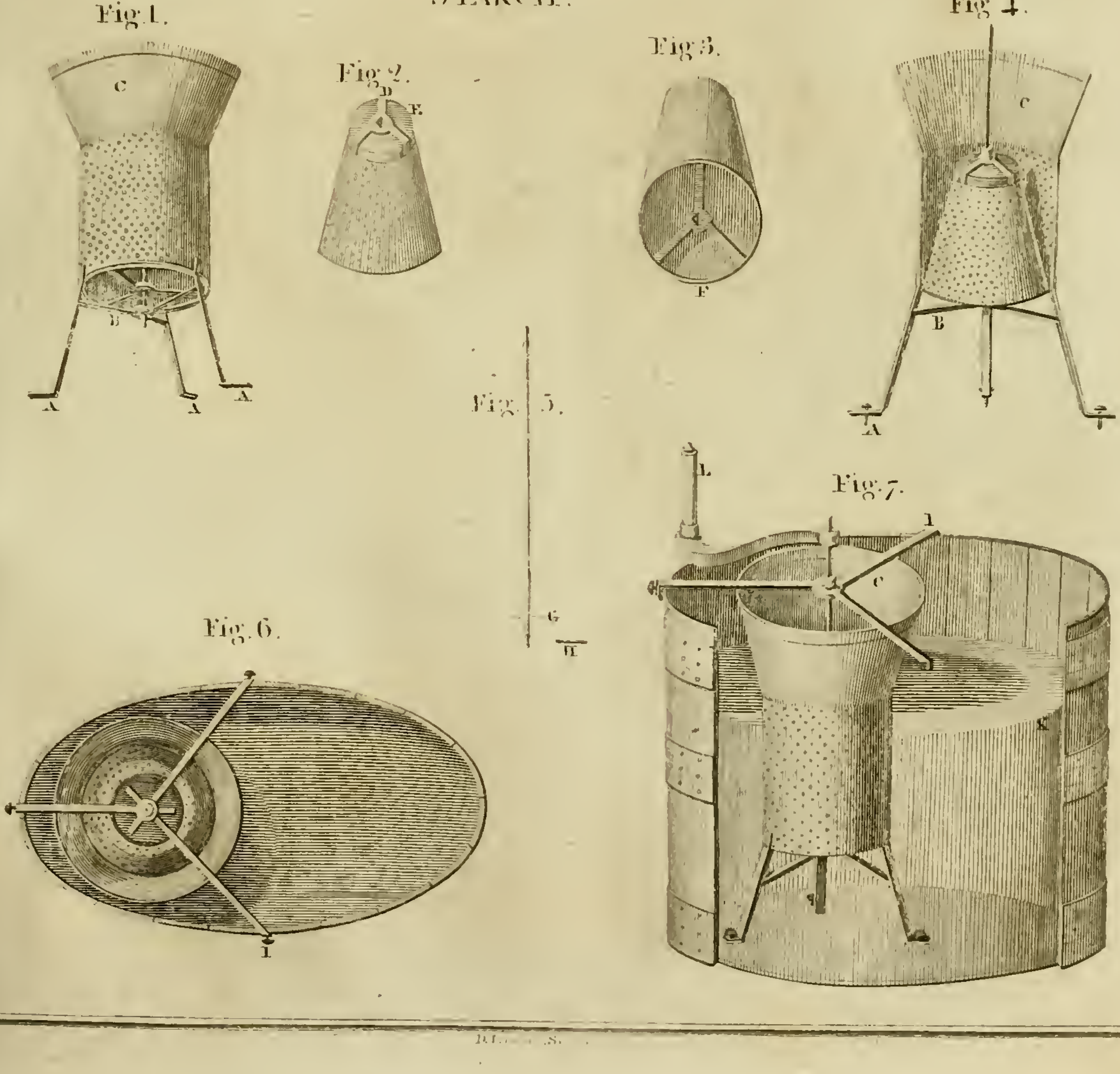
Fig. 1.
C
B
A
A
A
Fig. 2.
D
E
Fig. 3.
F
Fig. 4.
C
B
A
Fig. 5.
G
H
Fig. 6.
I
Fig. 7.
L
I
I
C
K

into it as high as K, and the top of the mill is to be filled with potatoes, properly washed and cut; the handle L is to be turned round, and the potatoes, after being ground between the two graters, go out gradually at the lower part, being assisted by the motion produced in the water by the action of the mill.

It is not necessary, in the construction of such a mill, to be very particular with respect to its proportions; but, in order to make known those which experience has proved to be good ones, a scale is given with the figures, to which recourse may be had. With a mill of this size, 100 pounds of potatoes may be ground in the space of two hours.

We are persuaded that this mill will answer perfectly well for grinding horse-chesnuts; and we hope, that where they can be had they will be used in preference to potatoes. We shall, however, give M. Beaumé's method of extracting starch from the ground potatoes, not only because it will be acceptable to those who have not horse-chesnuts, but also because those who have may, by following it, be able, perhaps, to make starch of them, without encroaching upon Lord William Murray's patent.

In order to prepare starch from potatoes, says M. Beaumé, any quantity of these roots may be taken, and soaked in a tub of water for about an hour; they are afterwards to have their fibres and shoots taken off, and then to be rubbed with a pretty strong brush, that the earth, which is apt to lodge in the inequalities of their surface, may be entirely removed; as this is done, they are to be washed, and thrown into another tub full of clean water. When the quantity which we mean to make use of has been thus treated, those which are too large are to be cut into pieces about the size of eggs, and thrown into the mill; that being already fixed in the oval tub, with the proper quantity of water; the handle is then turned round, and as the potatoes are grated they pass out at the bottom of the mill The pulp which collects about the mill must be taken off from time to time with a wooden spoon, and put aside in water.

When all the potatoes are ground, the whole of the pulp is to be collected in a tub, and mixed up with a great quantity of clean water. At the same time, another tub, very clean, is to be prepared, on the brim of which are to be placed too wooden rails, to support a hair sieve, which must not be too fine. The pulp and water are to be thrown into the sieve; the flour passes through with the water, and fresh quantities of water are successively to be poured on the remaining pulp, till the water runs through as clear as it is poured in. In this way we are to proceed till all the potatoes that were ground are used.

The pulp is commonly thrown away as useless; but it should be boiled in water, and used as food for animals; for it is very nourishing, and is about $\frac{7}{8}$ths of the whole quantity of potatoes used.

To return from this short digression, The liquor which has passed through the sieve is turbid, and of a brownish colour, on account of the extractive matter which is dissolved in it; it deposits, in the space of five or six hours, the flour which was suspended in it. When all the flour is settled to the bottom, the liquor is to be poured off and thrown away, being useless; a great quantity of very clan water is then to be poured upon the flour remaining at the bottom of the tub, which is to be stirred up in the water, that it may be washed, and the whole is to stand quiet till the day following. The flour will then be found to have settled at the bottom of the tub; the water is again to be poured off as useless, the flour washed in a fresh quantity of pure water, and the mixture passed through a silk sieve pretty fine, which will retain any small quantity of pulp which may have passed through the hair sieve. The whole must once more be suffered to stand quiet till the flour is entirely settled; if the water above it is perfectly clear and colourless, the flour has been sufficiently washed; but if the water has any sensible appearance either of colour or of taste, the flour must be again washed, as it is absolutely necessary that none of the extractive matter be suffered to remain.

When the flour is sufficiently washed, it may be taken out of the tub with a wooden spoon; it is to be placed upon wicker frames covered with paper, and dried, properly defended from dust. When it is thoroughly dry, it is to be passed through a silk sieve, that if any clotted lumps should have been formed they may be divided. It is to be kept in glass vessels stopped with paper only. See *Vegetable* SUBSTANCES, Suppl.

N. B. Almost all the flour of potatoes that is to be bought contains a small quantity of sand, which is perceived between the teeth; it is owing to the potatoes not having been properly washed; for the sand which lodges in the knobs and wrinkles of these roots, is not always easy to get out.

STARLINGS, or STERLINGS, the name given to the strong pieces of timber which were driven into the bed of the river to protect the piles, on the top of which were laid the flat beams upon which were built the bases of the stone piers that support the arches of London bridge. In general, starlings are large piles placed on the outside of the foundation of the piers of bridges, to break the force of the water, and to protect the stone work from injury by floating ice. They are otherwise called JETTES, which see in this *Supplement*; and their place is often supplied by large stones thrown at random round the piers of bridges, as may be seen at Stirling bridge when the river is low; and as was done by Mr Smeaton's direction round the piers of the centre arch of London bridge, when it was thought in danger of being undermined by the current. See SMEATON, *Encycl.*

STATIONARY, in astronomy, the state of a planet when, to an observer on the earth, it appears for some time to stand still, or remain immoveable in the same place in the heavens. For as the planets, to such an observer, have sometimes a progressive motion, and sometimes a retrograde one, there must be some point between the two where they must appear stationary.

STEAM, STEAM-ENGINE. The few following corrections of these articles in the *Encycl.* were communicated by the author.

Page 745. col. 1.—It was not at the York Building waterworks in London that the boiler burst, but in the country in an engine erected by Dr Desaguilliers. See his *Experimental Philosophy*, Vol. II. p. 489.

Page 746. col 2.—The condensation requires more cold water than is here allowed, as will appear by and bye; and we also suspect that the rapidity is overrated with which a great volume of steam is condensed by the cold furface of a veffel. We are well informed that Mr Watt was much difappointed in his expectations from a conftruction in which this mode of condenfation was adopted. The condenfer employed by Mr Cartwright (fee *Phil. Mag.*) was one of the very firft thought of and tried for this purpofe, and was given up, as well as all others on the fame principle ; and the immediate contact of cold water was preferred as incomparably more effective. The great fuperiority of the capacity of water for heat is now well known. It is true, that when we employ an extenfive cold furface of the condenfer, this furface is kept cold by the water round it ; and therefore we ftill avail ourfelves of this great avidity of water for heat. But this water muft act through the intervention of the veffel ; and the fubftance of the veffel does not convey heat to the furrounding water in an inftant.

Page 749. col. 2.—No diftinct experiment fhews fo great an expanfion of water, when converted into fteam at the temperature 212° ; and under the preffure of the air Mr Watt never found it more than 1800 times rarer than water.

Page 753. col. 1.—The heat expended in boiling off a cubic foot of water is about fix times as much as would bring it to a boiling heat from the medium temperature (55°) in this climate.

Page 758. col. 2.—The quantity of water neceffary for injection may be determined on principle, at leaft for an engine having a feparate condenfer. Every cubic foot of common fteam produces about an inch of water when condenfed, and contains about as much latent heat as would raife 1100 inches of water one degree. This fteam muft not only be condenfed, but muft be cooled to the temperature of the hot well ; therefore as many inches of cold water muft be employed as will require all this heat to raife it to the temperature of the hot well. Therefore let x be the cubic feet of fteam, or capacity of the cylinder, and let y be the inches of cold water expended in condenfing it. Let a be the difference between 212° and the temperature of the hot well, and b the difference between the temperature of the well and the injection ciftern. We have $y\,b = x \times \overline{1100 + a}$, or $y = \dfrac{\overline{1100 + a} \times x}{b}$.

Thus, if the temperature of the hot well be 100° (and it fhould never be higher, if we would have a tolerable vacuum in the cylinder), and that of the injection ciftern be 50°, we have $a = 112$, and $b = 50$, and $y = \dfrac{1212}{50}\,x, = 24{,}24\,x$, or $24\frac{1}{4}\,x$; that is, every foot of the capacity of the cylinder, or every inch of water evaporated from the boiler, requires more than 24 inches of water to condenfe the fteam. A wine pint for every inch of water boiled off, or every cubic foot of capacity of the cylinder, may be kept in mind, as a large allowance. Or, more exactly, if the engine be in good order, and the injection water as low as 50°, and the hot well not above 100°, we may allow 25 gallons of injection for one gallon of water boiled off. This greatly exceeds the quantity mentioned in the cafe of a good Newcomen's engine, the cylinder of which contained almoft 30 cubic feet of fteam. And this circumftance fhews the fuperiority of the engine with a feparate condenfer. The injection of Newcomen's engine had been adjufted by experience, fo as to make the beft compenfation for the unavoidable wafte in the cylinder. We prefume that this machine was not loaded above eight pounds per inch, more likely with feven ; whereas Watt's engine, working in the condition now defcribed, bears a load not much below twelve, making at leaft twelve ftrokes per minute.

This is not a matter of mere curiofity ; it affords a very exact rule for judging of the good working order of the engine. We can meafure with accuracy the water admitted into the boiler during an hour, without allowing its furface to rife or fall, and the water employed for injection. If the laft be below the proportion now given (adapted to the temperatures 50° and 100°), we are certain that fteam is wafted by leaks, or by condenfation in fome improper place. The rule is not ftrictly conformable to the latent heat of fteam which balances the atmofphere, 1100° being fomewhat too great a value. It is accommodated to the actual performance of Watt's engines, when in their beft working condition.

It is evident that it is of great importance to have the temperature of the hot well as low as poffible ; becaufe there always remains a fteam in the cylinder, of the fame, or rather higher temperature, poffeffing an elafticity which balances part of the preffure on the other fide of the pifton, and thus diminifhes the power of the engine. This is clearly feen by the barometer, which Mr Watt applies to many of his beft engines, and is a moft ufeful addition for the proprietor. It fhews him, in every moment, the ftate of the vacuum, and the real power of his engine, and tells him when there are leaks by which air gets in.

Page 762 cols. 1. 2.—Mr Watt's firft experiment was not exactly as here related, but much more analogous to the prefent form of his engine. The condenfer was a cylinder of tinplate, fitted with a pifton, which was drawn up from the bottom to the top, before the eduction cock was opened. Without this previous rarefaction in the condenfer, there was no inducement for the fteam to take this courfe, unlefs it were made much ftronger than that of ordinary boiling water.

The defcription of the firft form of the engine is alfo faulty, by the omiffion of a valve immediately below the eduction pipe. This valve is fhut along with the valve I, to prevent the fteam, which fhould then go into the lower part of the cylinder, from alfo going down into the condenfer. This is not abfolutely neceffary, but its advantage is evident.

Page 766. col. 1.—This form of the engine was very early put in practice by Mr Watt—about the year 1775. The fmall engine at Mr Boulton's works at Soho was erected in 1776 ; and the engine at Shadwell waterworks, one of the beft yet erected, had been working fome time when we faw it in 1778. We mention this, becaufe we have been told that Mr Hornblower puts in fome claim to priority in this invention. We do not think that Mr Hornblower erected any of his engines before 1782 ; and as Mr Hornblower was, we believe, working with Boulton and Watt before that time, we think it fully more probable that he has in this refpect profited by the inftruction of fuch intelligent employers. We may alfo obferve, that Mr Watt employed the fame contrivance which we have defcribed with much approbation in p. 772. *Encycl.* for keeping the

the collar round the piston rods steam and air tight. He found them effectual, but that they required more attention for keeping them in fit condition than the usual mode of packing. He made a similar packing for the piston, and with a similar result.

Page 769. cols. 1. 2.—Mr Boulton estimates the performance of the engines in the following manner. Seeing that the great expence of the engine is the consumption of fuel, he makes this the standard of computation, and estimates the performanee by the work which he *engages* to perform by the consumption of one bushel of good Newcastle coal, London measure, or containing 84 lbs. without regard to the time in which this bushel is expended. This depends on the size of the engine.

The burning one bushel of coal will,

1. Raise 30 million pounds one foot high.
2. It will grind and dress 11 bushels of wheat.
3. It will slit and draw into nail rods 5 cwt. of iron.
4. It will drive 1000 cotton spindles, with all the preparation machinery, with the proper velocity.
5. It is equivalent to the work of ten horses.

The general performance of the double stroke expansive engines is somewhat beyond this; and their performance in cotton spinning, or as compared with horse work, is much under-rated. The first estimation is without ambiguity. Suppose the engine of such a size as to consume a bushel of coals per hour. This will be found equivalent to raising 97 wine hogsheads of water ten feet high in a minute, which ten stout draught horses cannot do for a quarter of an hour together. They can raise 60 in that time, and work at this rate eight or perhaps ten hours from day to day.

Mr Watt finds that, with the most judiciously constructed furnaces, it requires eight feet of surface of the boiler to be exposed to the action of fire and flame to boil off a cubic foot of water in an hour, and that a bushel of coals so applied will boil off from eight to twelve cubic feet.

Boulton and Watt now make steam-engines equivalent in power to one or two horses. The cylinder and whole machinery does not occupy more room than a fine lady's working table, standing in a square of about $2\frac{1}{2}$ feet, and about 5 feet high.

STEEL (see that article *Encycl.* and CHEMISTRY, n° 114. *Suppl.*) is composed of iron and carbon. In addition to the old proofs which we had of this fact, it occurred to *Morveau*, alias *Guyton*, to attempt to convert soft iron into steel, by using the diamond instead of charcoal in the process of cementation. This expensive experiment, which was suggested by M. Clouet, was made, by inclosing within a small crucible of very soft iron a diamond, and shutting up the crucible by a stopper well adjusted. This crucible of iron, with its contents, was placed, without the addition of any surrounding matter, in a very small Hessian crucible, and the latter in a second crucible of the same earth; but the space between the two latter crucibles was filled with siliceous sand, free from all ferruginous particles. In the last place, the large crucible was luted with earth arising from pounded crucibles and unbaked clay, and the whole was exposed about an hour to a three blast forge fire. When the whole was cooled, the iron was found in the interior Hessian crucible converted into a solid ingot of cast steel. Thus the diamond disappeared by the affinity which iron exercised on it by the help of the high temperature to which they were both exposed, in the same manner as a metal disappears in the alloy of another metal. The diamond therefore furnished here the same principle as carbon, since the product of the union has the same properties.

The conversion into steel could not be doubted. The ingot having been polished on a lapidary's wheel, a drop of weak nitrous acid immediately produced a dark-grey spot, absolutely like that exhibited on English cast steel, and on cast steel produced by the process of M. Clouet. Those who have often tried steel by this kind of proof, long ago pointed out by Rinmann, had occasion to remark, that the spot of cast steel, tho' very sensible, is, however, less black than that of steel made by cementation, which depends perhaps on the different degree of oxydation of the carbon which they have taken in.

The process of M. Clouet here mentioned, for producing cast steel, consists in nothing more than throwing a quantity of glass into the mass of iron and charcoal during the formation of the former into steel. The same chemist has ascertained that iron, during its conversion into steel, absorbs 0.2013 of its weight of carbon; and that the affinity of iron for carbon is so strong, that, at a white heat, it is capable of decomposing carbonic acid gas. This he proved by the following experiment.

If six parts of iron be mixed with four parts of a mixture composed of equal quantities of carbonat of lime and clay, and kept in a crucible at a white heat for an hour or longer, according to the quantity, the iron will be converted into steel. The decomposition of carbonic acid is evidently the consequence of a compound affinity; part of the iron combining with the carbon, and another part with the oxygen of the carbonic acid gas. Accordingly the commissioners, who were appointed to examine the process, remark, that a quantity of oxide of iron was always mixed with the melted earthy substance, which was separated from the steel.

STEEVENS (George), the most successful of all the editors and commentators of Shakespeare, was born 1735. Of his parents we know nothing, but that they seem to have been in circumstances which may be deemed affluent. George received the rudiments of his classical education at Kingston-upon-Thames, under the tuition of Dr Woodeson and his assistants; and had for a companion at that school Gibbon the historian. From Kingston he went to Eton, whence, after some years, he was admitted a fellow-commoner of King's College, Cambridge; but with the course of his studies in the university we are not acquainted. If we might hazard a conjecture, from the manner in which he employed his riper years, we should suppose that he had little relish for those mathematical speculations which in Cambridge lead to academical honours. After he left the university, he accepted a commission in the Essex militia on its first establishment; and he spent the latter years of his life at Hampstead in almost total seclusion from the world; seldom mixing with society but in the shops of booksellers, in the Shakespeare Gallery, or in the morning *conversations* of Sir Joseph Banks. He died January 1800.

This

Steevens.

This is a very meagre account of the incidents which muſt have taken place in the life of a man ſo conſpicuous in the republic of letters; but we have had no opportunity of improving it. His character, as drawn in the Monthly Magazine, believing it to be juſt, we ſhall adopt, as it will ſupply in ſome degree the defects of our narrative.

Though Mr Steevens is known rather as a commentator than as an original writer; yet, when the works which he illuſtrated, the learning, ſagacity, taſte, and general knowledge which he brought to the taſk, and the ſucceſs which crowned his labours, are conſidered, it would be an act of injuſtice to refuſe him a place among the firſt literary characters of the age. Adorned by a verſatility of talents, he was indeed eminent both by his pen and his pencil. With the one there was nothing which he could not compoſe, and with the other there was nothing which he could not imitate ſo cloſely, as to leave a doubt which was the original and which the copy. But his chief excellence lay in his critical knowledge of an author's text; and the beſt ſpecimen of his great abilities is his edition of Shakeſpeare, in which he has left every competitor far behind him. He had, in ſhort, ſtudied the age of Shakeſpeare, and had employed his perſevering induſtry in becoming acquainted with the writings, manners, and laws of that period, as well as the provincial peculiarities, whether of language or cuſtom, which prevailed in different parts of the kingdom, but more particularly in thoſe where Shakeſpeare paſſed the early years of his life. This ſtore of knowledge he was continually increaſing, by the acquiſition of the rare and obſolete publications of a former age, which he ſpared no expence to obtain; while his critical ſagacity and acute obſervation were employed inceſſantly in calling forth the hidden meanings of the great dramatic bard, from their covert, and conſequently enlarging the diſplay of his beauties. This advantage is evident from his laſt edition of Shakeſpeare, which contains ſo large a portion of new, intereſting, and accumulated illuſtration. In the preparation of it for the preſs, he gave an inſtance of editorial activity and perſeverance which is without example. To this work he devoted ſolely, and excluſively of all other attentions, a period of 18 months; and during that time he left his houſe every morning at one o'clock with the Hampſtead patrole, and proceeded, without any conſideration of the weather or the ſeaſon, to his friend Mr Iſaac Read's chambers, in Barnard's Inn, where he was allowed to admit himſelf, and found a room prepared to receive him, with a ſheet of the Shakeſpeare letter preſs ready for correction. There was every book which he might wiſh to conſult; and to Mr Read he could apply, on any doubt or ſudden ſuggeſtion, as to a man whoſe knowledge of Engliſh literature was perhaps equal to his own. This nocturnal toil greatly accelerated the printing of the work; as while the printers ſlept the editor was awake; and thus, in leſs than twenty months, he completed his laſt ſplendid edition of Shakeſpeare, in fifteen large octavo volumes; an almoſt incredible labour, which proved the aſtoniſhing energy and perſevering powers of his mind.

That Mr Steevens contented himſelf with being a commentator, aroſe probably from the habits of his life, and his devotion to the name, with which his own will deſcend to the lateſt poſterity. It is probable that many of his *jeux d'eſprit* might be collected: there is a poem of his in Dodſley's Annual Regiſter, under the title of *The Frantic Lover*, which is ſuperior to any ſimilar production in the Engliſh language. Mr Steevens was a claſſical ſcholar of the firſt order. He was equally acquainted with the belles lettres of Europe. He had ſtudied hiſtory, ancient and modern, but particularly that of his own country. He poſſeſſed a ſtrong original genius, and an abundant wit; his imagination was of every colour, and his ſentiments were enlivened with the moſt brilliant expreſſions. His colloquial powers ſurpaſſed thoſe of other men. In argument he was uncommonly eloquent: and his eloquence was equally logical and animated. His deſcriptions were ſo true to nature, his figures were ſo finely ſketched, of ſuch curious ſelection, and ſo happily grouped, that he might be conſidered as a ſpeaking Hogarth. He would frequently, in his ſportive and almoſt boyiſh humours, condeſcend to a degree of ribaldry but little above O'Keefe—with him, however, it loſt all its coarſeneſs, and aſſumed the air of claſſical vivacity. He was indeed too apt to catch the ridiculous, both in characters and things, and indulge an indiſcreet animation wherever he found it. He ſcattered his wit and his humour, his gibes and his jeers, too freely around him, and they were not loſt for want of gathering.

Mr Steevens poſſeſſed a very handſome fortune, which he managed with diſcretion, and was enabled by it to gratify his wiſhes, which he did without any regard to expence, in forming his diſtinguiſhed collections of claſſical learning, literary antiquity, and the arts connected with it. His generoſity alſo was equal to his fortune; and though he was not ſeen to give eleemoſynary ſixpences to ſturdy beggars or ſweepers of the croſſings, few perſons diſtributed bank-notes with more liberality; and ſome of his acts of pecuniary kindneſs might be named, which could only proceed from a mind adorned with the nobleſt ſentiments of humanity. He poſſeſſed all the grace of exterior accompliſhment, acquired at a period when civility and politeneſs were characteriſtics of a gentleman.

He has bequeathed his valuable Shakeſpeare, illuſtrated with near 1500 prints, to Lord Spencer; his Hogarth perfect, with the exception of one or two pieces, to Mr Windham; and his corrected copy of Shakeſpeare, with 200 guineas, to his friend Mr Read.

Steevens, Stereometer.

STEREOMETER, an inſtrument lately invented in France for meaſuring the volume of a body, however irregular, without plunging it in any liquid. If the capacity of a veſſel, or, which is the ſame thing, the volume of air contained in that veſſel, be meaſured, when the veſſel contains air only, and alſo when the veſſel contains a body whoſe volume is required to be known, the volume of air aſcertained by the firſt meaſurement, deducting the volume aſcertained by the ſecond, will be the volume of the body itſelf. Again, if it be admitted as a law, that the volume of any maſs of air be inverſely as the preſſure to which it is ſubjected, the temperature being ſuppoſed conſtant, it will be eaſy to deduce, from the mathematical relations of quantity, the whole bulk, provided the difference between the two bulks under two known preſſures be obtained by experiment.

Let it be ſuppoſed, for example, that the firſt preſſure is double the ſecond, or, which follows as a conſequence,

quence, that the ſecond volume of the air be double the firſt, and that the difference be fifty cubic inches, it is evident that the firſt volume of the air will likewiſe be fifty cubic inches. The ſtereometer is intended to aſcertain this difference at two known preſſuers.

Plate XLIII.

The inſtrument is a kind of funnel AB (fig. 1.), compoſed of a capſule A, in which the body is placed, and a tub B as uniform in the bore as can be procured. The upper edge of the capſule is ground with emery, in order that it may be hermetically cloſed with a glaſs cover M ſlightly greaſed. A double ſcale is paſted on the tube, having two ſets of graduations; one to indicate the length, and the other the capacities, as determined by experiment.

When this inſtrument is uſed, it muſt be plunged in a veſſel of mercury with the tube very upright, until the mercury riſes within and without to a point C of the ſcale. See fig. 2.

The capſule is then cloſed with the cover, which being greaſed will prevent all communication between the external air and that contained within the capſule and tube.

In this ſituation of the inſtrument, in which the mercury ſtands at the ſame height within and without the tube, the internal air is compreſſed by the weight of the atmoſphere, which is known and expreſſed by the length of the mercury in the tube of the common barometer.

The inſtrument is then to be elevated, taking care to keep the tube conſtantly in the vertical poſition. It is repreſented in this ſituation, fig. 2. ſecond poſition. The mercury deſcends in the tube, but not to the level of the external ſurface, and a column DE of mercury remains ſuſpended in the tube, the height of which is known by the ſcale. The interior air is therefore leſs compreſſed than before, the increaſe of its volume being equal to the whole capacity of the tube from C to D, which is indicated by the ſecond ſcale.

It is known therefore that the preſſures are in proportion to the barometrical column, and to the ſame column diminiſhed by the ſubtraction of DE. And the bulks of the air in theſe two ſtates are inverſely in the ſame proportion; and again the difference between theſe bulks is the abſolute quantity left void in the tube by the fall of the mercury; from which data, by an eaſy analytical proceſs, the following rule is deduced: Multiply the number which expreſſes the leſs preſſure by that which denotes the augmentation of capacity, and divide the product by the number which denotes the difference of the preſſures. The quotient will be the bulk of the air when ſubject to the greater preſſure.

To render this more eaſy by an example, ſuppoſe the height of the mercury in the barometer to be 78 centimetres, and the inſtrument being empty to be plunged in the mercury to the point C. It is then covered, and raiſed until the ſmall colum of mercury DE is ſuſpended, for example, at the height of ſix centimetres. The internal air, which was the firſt compreſſed by a force repreſented hy 78 centimetres, is now compreſſed only by a force repreſented by 78 − 6, or 72 centimetres.

Suppoſe it to be obſerved, at the ſame time, by means of the graduations of the ſecond ſcale, that the capacity of the part CD of the tube which the mercury has quitted is two cubic centimetres. Then by the rule $\frac{72}{6} \times 2$ give 24 cubical centimetres, which is the volume of the air included in the inſtrument when the mercury roſe as high as C in the tube.

The body of which the volume is to be aſcertained muſt then be placed in the capſule, and the operation repeated. Suppoſe, in this caſe, the column of mercury ſuſpended to be eight centimetres, when the capacity of the part CD of the tube is equal to two centimetres cube. Then the greateſt preſſure being denoted by 78 centimetres, as before, the leaſt will be 70 centimetres, the difference of the preſſures being 8, and the difference of the volumes two cubical centimetres. Hence $\frac{70}{8} \times 2$ gives the bulk of the included air under the greateſt preſſure 17,5 cubic centimetres. If therefore 17,5 centimetres be taken from 24 centimetres, or the capacity of the inſtrument when empty, the difference 6,5 cubic centimetres will expreſs the volume of the body which was introduced. And if the abſolute weight of the body be multiplied by its bulk in centimetres, and divided by the abſolute weight of one cubic centimetre of diſtilled water, the quotient will expreſs the ſpecific gravity of the body in the common form of the tables where diſtilled water is taken as unity, or the term of compariſon.

After this deſcription and explanation of the uſe of his inſtrument, the author proceeds with the candour and acuteneſs of a philoſopher to aſcertain the limits of error in the reſults; an object ſeldom ſufficiently attended to in the inveſtigation of natural phenomena. From his reſults it appears, that with the dimenſions he has aſſumed, and the method preſcribed for operating, the errors may affect the ſecond figure. He likewiſe gives the formulæ by means of which the inſtrument itſelf may be made to ſupply the want of a barometer in aſcertaining the greateſt preſſure. He likewiſe adverts to the errors which may be produced by change of temperature. To prevent theſe as much as poſſible, the actual form of the inſtrument and arrangements of its auxiliary parts are ſettled, as in fig. 3. by which means the approach of the hand near the veſſel and its tube is avoided. In this figure the vertical poſition of the tube is ſecured by the ſuſpenſion of the veſſel, and a perforation in the table through which the tube paſſes. The table itſelf ſupports the capſule in its firſt poſition, namely, that at which the cover is required to be put on.

Mr Nicholſon, from whoſe Journal this abſtract is immediately taken, ſuppoſes, with great probability, that the author of the invention had not finiſhed his meditations on the ſubject, when the memoir giving an account of it was publiſhed. If he had, ſays the ingenious journaliſt, it is likely that he would have determined his preſſures, as well as the meaſures of bulks by weight. For it may be eaſily underſtood, that if the whole inſtrument were ſet to its poſitions by ſuſpending it to one arm of a balance at H (fig. 3.), the quantity of counterpoiſe, when in equilibrio, might be applied to determine the preſſures to a degree of accuracy much greater than can be obtained by linear meaſurement.

STEWART-Denham (Sir James) was born at Edinburgh on the 10th of October, O. S. in the year 1713. His father was Sir James Stewart of Goodtrees, Bart. Solicitor-general for Scotland; and his mother

ther was Anne, daughter of Sir Hugh Dalrymple of North Berwick, Bart. prefident of the college of juftice.

The firft rudiments of his education he received at the grammer-fchool of North-Berwick, which at the time of his father's death he quitted at the age of fourteen, with the reputation of being a good fcholar, but without any extraordinary advancement in knowledge.

It is remarkable, that many men who have been fingularly ufeful to fociety have not fhewn early fymptoms of the greatnefs of their intellectual powers. A great underftanding muft be the offspring of happy organization in a healthy body, with co-operation of time, of circumftance, and of inftitution, without being forced into prematurity by exceffive cultivation. This holds with refpect to the growth and perfection of every creature; and the truth appears remarkable with refpect to our own fpecies, becaufe we are apt to miftake the flimfy attainments of artificial education for the fteady and permanent foundations of progreffive knowledge.

From the fchool of North-Berwick Sir James was fent to the univerfity of Edinburgh, where he continued until the year 1735, when he paffed advocate before the court of Seffion, and immediately afterwards went abroad to vifit foreign countries. He was then in the 23d year of his age, had made himfelf well acquainted with the Roman law and hiftory, and the municipal law of Scotland. He had likewife maturely ftudied the elements of jurifprudence; was verfed in the general, as well as the particular, politics of Europe; and was bent upon applying his knowledge to the inveftigation of the ftate of men and of manners in other nations, with a view to promote the benefit of his own, and to confirm himfelf in the love of a free conftitution of government, by contemplating the baneful effects of unlimited monarchy in Germany, Italy, and Spain, and of extravagant attachment to a king and nobility, to war, and to pernicious fplendour in France.

He travelled firft, however, into Holland, with a view to ftudy the conftitution of the empire before he fhould vifit Germany, and to attend fome of the lectures of the moft eminent profeffors at Utrecht and Leyden, on public law and politics. From thence he paffed into Germany, refided about a year in France, travelled thro' fome part of Spain, where he had a fever, that obliged him, for his perfect recovery from its effects, to go by the advice of his friends to the fea-coaft of the lovely province of Valentia; thence returning, he croffed the Alps, and by Turin made the tour of Italy, where chiefly at Rome and Florence he refided till the beginning of the year 1740; when, having fpent five years on his travels, he returned to Scotland, and married the Lady Frances Wemyfs, eldeft daughter of the Earl of Wemyfs, about two years after his return.

A few months after his marriage the reprefentation of the county of Mid-Lothian became vacant, by the member being made a Lord of trade and plantation. The candidates were the late member and Sir John Baird of Newbyth. On the day of election Mr Dundas of Arnifton, one of the fenators of the college of juftice, was chofen prefes of the meeting; and fome how or other omitted to caufe the name of Sir James Stewart to be called on the roll of freeholders. For this illegal ufe of his temporary power, Sir James commenced a fuit againft the prefident; and refuming the gown as an advocate, pleaded his own caufe with great energy and eloquence, and with the applaufe of the bench, the bar, and the public. This called Lord Arnifton from the bench to plead in his own defence at the bar; and Sir James could not have been oppofed to an antagonift better qualified to call forth all his powers; for that judge is talked of at this day in Edinburgh as the profoundeft lawyer and the ableft pleader that ever graced the Scottifh bench or the Scottifh bar.

With the iffue of this conteft we are not acquainted; but it drew upon Sir James Stewart very general attention, and convinced the public, that had he continued at the bar, he muft have rifen rapidly to the head of his profeffion. On his travels, however, he had contracted friendfhips with Lord Marifchal, and other eminent men, attached to the pretenfions of the royal family of Stuart, and had received flattering attentions from the Pretender to the Britifh throne; the impreffion arifing from which, added to the irritations of his controverfy with the powerful party in Scotland attached to the court, led him, unadvifedly, into connections with the movers of the rebellion in 1745.

As he was by far the ableft man of their party, the Jacobites engaged him to write the Prince Regent's manifefto, and to affift in his councils. Information having been given of his participation in thefe affairs, he thought it prudent, on the abortion of this unhappy attempt, to leave Britain; and by the zeal, it is faid, of Arnifton, he was excepted afterwards from the bill of indemnity, and rendered an exile from his country.

He chofe France for his refidence during the ten firft years of his banifhment, and was chiefly at Angoulefme, where he fuperintended the education of his fon; from thence he went to Tubingen in Swabia, for the benefit of its univerfity, in profecution of the fame dutiful and laudable defign; but in the end of the war 1756, having been fufpected by the court of Verfailles of communicating intelligence to the court of London, he was feized at Spa, and kept fome time in confinement; from which being liberated, after the acceffion of the prefent king of Great Britain, he came, by toleration, to England, and refided at London, where he put the laft hand to his Syftem of Political Economy, the copy-right of which he fold to Andrew Millar; and being permitted to dedicate this work to the king, he applied for a *noli profequi*, which, after fome malicious objections, he obtained, and had the comfort of returning to his family eftate in Scotland.

Having nothing profeffional to do during his long refidence in France, the active mind of Sir James was occupied in ftudy. His book on the Principles of Political Economy contains moft of the fruits of it. He turned himfelf, in the intervals of leifure, to confider the refources of France, that he might the better compile that part of his great work which was to treat of revenue and expenditure. It was by ftudying the language of the finances, without which nobody can afk a proper queftion concerning them, fo as to be underftood, that he attained his great purpofe.

As foon as he could afk queftions properly, he applied in familiar converfation to the intendants and their fubftitutes in the provinces where he refided, whom he found extremely defirous to learn the ftate of the Britifh finances, under the branches of the land-tax, cuftoms, excife, and other inland duties. This led him to

compare

Stewart-Denham.

compare the ftate of the two nations. The information he gave was an equivalent for the information he received; curiofity balanced curiofity, each was fatisfied and inftructed. The department of the intendants in France was confined to the taxes which compofed the *recettes generales*, namely, the *taille*, the *capitation*, and the *twentieths*, or *vigntiemes*. All the intendants had been *Maitres des Requetes*, bred at Paris, and could not fail to have much knowledge of the general *fermes* and other branches of the revenue. He carefully noted down at all times the anfwers he got; and when he came to refide at Paris, he obtained more ample information, both from the gentlemen of the revenue, and from perfons of the parliament of Paris, who to the number of 25 had been for 15 months exiled in the province where he had fo long refided at Angoulefme.

With thefe advantages, with much ftudy and attention to arrangement, he was enabled to compofe the fixth chapter of the fourth part of the fourth book of his Syftem of Political Economy; a portion of that great work well worthy the attention of thofe who wifh to know the ftate of France in refpect of revenue under the old government.

Although Sir James Stewart's leifure, during the firft ten years of his exile, was chiefly employed in focial intercourfe with the moft learned, elegant, and polifhed characters in France, who delighted in the converfation and friendfhip of a man who poffeffed at once immenfe information, on almoft every fubject, important or agreeable to fociety, and the talent of clearly and beautifully expreffing his fentiments in flowing and animated converfation; yet he did not allow the pleafures of the circle and of the table to blunt the fine feelings of a man of genius and fcience. The labour of collecting materials for his great political work was oppreffive, and he relieved himfelf with various enquiries, fuited to the exalted ambition of his cultivated underftanding, while he turned the charms of converfation to the permanent delight of his affociates and of pofterity. The motto of Apelles, "*Nulla dies fine linea*," was the emblem of his employment; and it is amazing what may be done by daily attention for improvement, without appearing to abftract any extraordinary time from the common offices and rational pleafures of fociety.

In the beginning of the year 1755, Sir James wrote his Apology, or Defence of Sir Ifaac Newton's Chronology, which at that time he intended to publifh, but was prevented by other engagements. It was communicated to feveral perfons of eminence in France and Germany in MS. and produced, in the month of December that year in the "*Mercure de France*," an anfwer from M. Defhoulieres, to which Sir James foon after replied.

The great Newton, applying aftronomical and ftatiftical principles to the ancient chronology of Greece, had chaftifed the vanity of nations, and arrefted the progrefs of infidelity in delineating the hiftory of the world. Loft in the confufion of exceffive pretenfions to an antiquity beyond all meafure, and difgufted by the fuperftitious aids that were affumed to fupport thefe pretenfions among ancient nations, the revivers of learning in Europe, during the laft and the preceding century, turmoiled themfelves with controverfies between the comparative merits of the ancients and moderns; and the abettors of the latter, entrenching themfelves behind the falfehoods of the ancients, on the fcope of their remote hiftory, gave the lie to all antiquity, and in defpair plunged themfelves into the ocean of fcepticifm.

Happy had it been for fociety if this fcepticifm had confined itfelf to the hiftory of ancient nations in general; but the fame fpirit, taking difguft at the horrors of Chriftian ambition and bigotry, and contemplating with derifion the ridiculous legends of modern miracles, gave the lie to all religious fcripture of the Jews and Chriftians, and attempted to banifh divine intelligence, the fuperintending providence of Deity, and the true dignity of the human fpecies, from the face of the earth!

It was a noble undertaking, therefore, in Sir James, to attempt to difperfe this mift of error, by difpaffionately and fcientifically explaining and fupporting the chronology of Sir Ifaac Newton. He has done it with great precifion and effect; and it is a book well worth the perufal of thofe who wifh to read ancient hiftory with improvement, or to prevent themfelves from being bewildered in the mazes of modern conjecture. It was printed in 4to at Franckfort on the Maine, for John Bernard Eichemberg the Elder, in 1757.

In the year 1758, and the following, the Britifh Houfe of Commons took up the confideration of a ftatute to regulate a general uniformity of weights and meafures throughout the united kingdoms, which had been fo often unfuccefsfully attempted.

This called the attention of Sir James, not only to the inveftigation of the particular fubject that engaged that of the Houfe of Commons, but to devife a method of rendering an uniformity of weights and meafures univerfal. He thought the caufe of former difappointments in this ufeful purfuit had been the miftaken notion that one or other of our prefent meafures fhould be adopted for the new ftandard. After the plan had been relinquifhed by the parliament of England, he digefted his notes and obfervations on this important difquifition into the form of an epiftolary differtation, which he tranfmitted to his friend Lord Barrington, and refolved, if there had been a congrefs affembled, as was once propofed, to adjuft the preliminaries of the general peace in 1763, to have laid his plan before the minifters of the different nations, who were to prepare that falutary pacification of the contending powers.

This epiftolary differtation Sir James afterwards reduced at Coltnefs, in the year 1777, into a form more proper for the public eye, and fent a corrected copy to a friend, referving another for the prefs, which was printed 1790 for Stockdale in Piccadilly.

In this tract the author fhews, from the ineffectual attempts that have been made to alter partially, by innovation, the ftandards of meafures or weights, that the effectual plan to be adopted, is to depart entirely from every meafure whatfoever now known, and to take, *ad libitum*, fome new mafs inftead of our pound, fome new length inftead of our ell, fome new fpace inftead of our acre, and fome new folid inftead of our gallon and bufhel.

For this purpofe Sir James propofes as the unit a mafs to be verified with the greateft poffible accuracy, equal in weight to ten thoufand Troy grains. The pendulum, as it fwings at London, to beat feconds of time,

time, he propofes to be the meafure of length; and after having laid down his fundamental principles, he propofes an ingenious plan for rendering their adoption univerfal through the whole world.

Having obtained his pardon, Sir James Stewart retired to Coltnefs, in the county of Lanark, the paternal eftate of his family, where he turned his attention to the improvement of his neighbourhood by public works and police, and drew the firft good plan for a turnpike bill, fuited to the circumftances of Scotland, which has been fince generally adopted. He repaired his houfe, planted, improved, and decorated his eftate, and in focial intercourfe rendered himfelf the delight of his neighbourhood and country.

Never was there a man who, with fo much knowledge, and fo much energy of expreffion in converfation, rendered himfelf more delightful to his company, or was more regretted by his acquaintance when he died. Nor was the active mind of Sir James unemployed for the general benefit of his country during his retreat. He was engaged by the directors of the Eaft India Company of England to digeft a cod for the regulation of the current coin of Bengal; the plan for which important regulation he printed, and received from the court of directors a handfome diamond ring, as a mark of their approbation.

He prepared for the prefs, but never publifhed, an antidote to the *Syfteme de law Nature* by Mirabeau, wherein the parallelogifms and foolifh reafoning of that infidel work are examined, detected, and confuted. It is written in French; and were the work of Mirabeau worth refutation, might be printed with much advantage to Sir James's reputation as a controverfial writer.

This great and good man died in November 1780, and was buried at Cambufnethan, in Lanarkfhire, on the 28th of the fame month; the Duke of Hamilton and his neighbours performing the laft offices to the remains of their highly valued friend, and bedewing his afhes with their tears.

For this fhort fketch of the principle events in the life of Sir James Stewart-Denham, we are indebted to his nephew the Earl of Buchan, who, juftly proud of his relation to fuch a man, cannot be fuppofed to view all his projects, or even all his reafonings, with the cool impartiality of ftrangers. His plan, for inftance, of a univerfal ftandard of weights and meafures for the *whole world*, though certainly a grand conception, we cannot help confidering as romantic and impracticable. The author indeed was fenfible, that time would be requifite for its execution; and fo large a portion of time, that, compared with it, a thoufand years are but as one day, when compared with the ordinary life of man: but fchemes of this magnitude are not for creatures fo blind and weak as we are, who, when we wander to a diftance beyond the limits of our narrow fphere, with the ambitious view of benefiting pofterity, are almoft certain to injure ourfelves, without a probability of ferving thofe for whom we dream that we are exerting our abilities. Sir James's Political Economy, however, is a very great work, which has not received half the praifes to which it is entitled, and which, we fufpect, provoked the envy of another great writer on fimilar fubjects, who exerted himfelf privately to leffen its fame. The defence of Newton's chronology is likewife very valuable, though we certainly do not think that part of the fyftem invulnerable, in which the great aftronomer attempts to prove, that *Ofiris*, *Sefoftris*, and *Sefac*, are three names of the fame Egyptain king. This, however, is a very trifling miftake; and the modern fciolift, who can lay hold of it to reject the whole, has certainly never read, or, if he has read, does not underftand the defence of the fyftem by Sir James Stewart.

SUBCONTRARY POSITION, in geometry, is when two equiangular triangles are fo placed, as to have one common angle at the vertex, and yet their bafes not parallel; confequently the angles at the bafes are equal, but on the contrary fides.

SUBDUCTION, in arithmetic, the fame as *Subtraction*.

ANIMAL AND VEGETABLE SUBSTANCES.

THE reader will recollect, that the article CHEMISTRY, in this *Supplement*, was divided into four parts; of which only the firft three, comprehending the elements of the fcience, were given under the word CHEMISTRY. The *fourth part*, which was entitled an examination of bodies as they are prefented to us by nature in the mineral, vegetable, and animal kingdoms, naturally fubdivides itfelf into three parts, comprehending refpectively, 1. Minerals; 2. Vegetables; 3. Animals.

1 Nature of the article.

The firft of thefe fubdivifions, which has been deftinguifhed by the name of MINERALOGY, we have treated of already in a former part of this volume. As the other two fubdivifions have not hitherto received any appropriate name, we have fatisfied ourfelves with the word SUBSTANCE, by which chemifts have agreed to denote the objects which belong to thefe dubdivifions. This name, it muft be acknowledged, is not unexceptionable; but we did not confider ourfelves as at liberty to invent a new one.

2 Divifion of it.

The prefent article, then, feems to divide itfelf into two parts: the firft part comprehending *vegetable*; the fecond *animal* fubftances. But there are certain animal and vegetable fubftances diftinguifhed from all others by being ufed as articles of clothing. It is ufual to tinge thefe of various colours, by combining with them different colouring matters for which they have an affinity. This procefs, well known by the name of DYEING, is purely chemical; and as it belongs exclufively to animal and vegetable fubftances, it comes naturally to be examined here. We fhall therefore add a *third part*, in which we fhall give a view of the prefent ftate of DYEING, as far, at leaft, as is confiftent with the nature of a fupplementary article.

PART

PART I. OF VEGETABLE SUBSTANCES.

Sugar.

VEGETABLES, or plants, as they are alfo called, are too well known to require any definition. Their number is prodigious, and their variety, regularity, and beauty, are wonderful. But it is not our intention in this place either to enumerate, to defcribe, or to claffify plants. Thefe tafks belong to the botanift, and have been fuccefsfully accomplifhed by the zeal, the fingular addrefs, and the indefatigable labour of Linnæus and his followers.

3 Chemical examination of vegetables. It is the bufinefs of the chemift to analyfe vegetables, to difcover the fubftances of which they are compofed, to examine the nature of thefe fubftances, to inveftigate the manner in which they are combined, to detect the proceffes by which they are formed, and to afcertain the chemical changes to which plants, after they have ceafed to vegetate, are fubject. Hence it is evident, that a chemical inveftigation of plants comprehends three particulars:

1. An account of the *fubftances* of which plants are compofed.

2. An account of the *vegetation* of plants, as far as it can be illuftrated by chemiftry.

3. An account of the *changes* which plants undergo after they ceafe to vegetate.

We therefore divide this part into three chapters, affigning a chapter to each of thefe particulars.

CHAP. I. OF THE INGREDIENTS OF PLANTS.

THE fubftances hitherto found in the vegetable kingdom, all of them at leaft which have been examined with any degree of accuracy, may be reduced to the following heads:

1. Sugar,	10. Camphor,
2. Starch,	11. Refins,
3. Gluten,	12. Caoutchouc,
4. Albumen,	13. Wax,
5. Gum,	14. Wood,
6. Jelly,	15. Acids,
7. Extract,	16. Alkalies,
8. Tan,	17. Earths,
9. Oils,	18. Metals.

Thefe fhall form the fubject of the following fections:

SECT. I. *Of SUGAR.*

SUGAR, which at prefent forms fo important an article in our food, feems to have been known at a very early period to the inhabitants of India and China.

4 Difcovery of fugar. But Europe probably owes it acquaintance with it to the conquefts of Alexander the Great. For ages after its introduction into the weft, it was ufed only as a medicine; but its confumption gradually increafed, and during the time of the Crufades the Venetians, who brought it from the eaft, and diftributed it to the northern parts of Europe, carried on a lucrative commerce with fugar. It was not till after the difcovery of America, and the extenfive cultivation of fugar in the Weft Indies, that its ufe in Europe, as an article of food, became general *.

* See *Falconer's Hiftory of Sugar. Manchefter Memoirs*, iv. 291. and *Mozeley's Hiftory of Sugar.*

Sugar is obtained from the *arundo faccharifera*, or *fugar cane*. The juice of this plant is preffed out and boiled in as low a temperature as poffible, till the fugar precipitates in the form of confufed cryftals. Thefe

5 How obtained. cryftals, known by the name of *raw fugar*, are again diffolved in water, the folution is clarified, and purer cryftals are obtained by a fubfequent evaporation. But for the particulars of the art of manufacturing fugar, we refer the reader to the article SUGAR in the *Encyclopædia*.

6 Its properties. Sugar, after it has been purified, or *refined* as the manufacturers term it, is ufually fold in Europe in the form of a white opake mafs, well known by the name of *loaf fugar*. Sometimes alfo it is cryftallized, and then it is called *fugar candy*.

Sugar has a very ftrong fweet tafte; when pure it has no fmell; its colour is white, and when cryftallized it is fomewhat tranfparent. It has often a confiderable degree of hardnefs; but it is always fo brittle that it can be reduced without difficulty to a very fine powder. It is not altered by expofure to the atmofphere.

7 Solubility in water. It is exceedingly foluble in water. At the temperature of 48°, water, according to Mr Wenzel, diffolves its own weight of fugar. The folvent power of water increafes with its temperature; when nearly at the boiling point, it is capable of diffolving any quantity of fugar whatever. Water thus faturated with fugar is known by the name of *fyrup*.

Syrup is thick, ropy, and very adhefive; when fpread thin upon paper, it foon dries, and forms a kind of varnifh, which is eafily removed by water. Its fpecific caloric, according to the experiments of Dr Crawford, is 1.086.

8 Its cryftals. When fyrup is fufficiently concentrated, the fugar which it contains precipitates in cryftals. The primitive form of thefe cryftals is a four-fided prifm, whofe bafe is a rhomb, the length of which is to its breadth as 10 to 7; and whofe height is a mean proportion between the length and breadth of the bafe. The cryftals are ufually four or fix-fided prifms, terminated by two-fided, and fometimes by three-fided fummits †.

† *Gillot, Ann. de Chim.* xviii. 317.

9 Solubility in alcohol. Sugar is foluble in alcohol, but not in fo large a proportion as in water. According to Wenzel, four parts of boiling alcohol diffolve one of fugar §. It unites readily with oils, and renders them mifcible with water. A moderate quantity of it prevents, or at leaft retards, the coagulation of milk; but Scheele difcovered that a very large quantity of fugar caufes milk to coagulate ‖.

§ *Enc. Meth. Chim.* i. 271.

‖ *Scheele* ii. 52. Dijon tranflation.

Sugar abforbs muriatic acid gas flowly, and affumes a brown colour and very ftrong fmell ‡.

‡ *Prieftley*, ii. 291.

10 Action of acids. Sulphuric acid, when concentrated, readily decompofes fugar; water is formed and perhaps alfo acetous acid; while charcoal is evolved in great abundance, and gives the mixture a black colour, and a confiderable degree of confiftency. The charcoal may be eafily feparated by dilution and filtration. When heat is applied, the fulphuric acid is rapidly converted into fulphurous acid.

11 Of potafs. When fugar is mixed with potafs, the mixture acquires a bitter and aftringent tafte, and is infoluble in alcohol, though each of the ingredients is very foluble in that liquid. When the alkali is faturated with fulphuric

Sugar. ric acid, and precipitated by means of alcohol, the fweet tafte of the fugar is reftored; a proof that it had undergone no decompofition from the action of the potafs, but had combined with it in the ftate of fugar*.

* Cruickfhank, Rollo on Diabetes, p. 442.

12 Of lime. Lime boiled with fugar produces nearly the fame effect as potafs; when an alkali is added to the compound, a fubftance precipitates in white flakes. This fubftance is fugar combined with lime†. Sugar and chalk compofe, as Leonardi informs us, a kind of cement‡.

† Ibid.

‡ Encyc. Meth. Chim. i. 271.

13 Of heat. Sugar, when thrown upon a hot iron, melts, fwells, becomes brownifh black, emits air bubbles, and exhales a peculiar fmell, known in French by the name of *caromel*. At a red heat it inftantly burfts into flames with a kind of explofion. The colour of the flame is white with blue edges.

14 Diftillation of it. When fugar is diftilled in a retort, there comes over a fluid which, at firft, fcarcely differs from pure water; by and bye it is mixed with pyromucous acid, afterwards fome empyreumatic oil makes its appearance; and a bulky charcoal remains in the retort. This charcoal very frequently contains lime, becaufe lime is ufed in refining fugar; but if the fugar, before being fubmitted to diftillation, be diffolved in water, and made to cryftallize by evaporation in a temperature fcarcely higher than that of the atmofphere, no lime whatever, nor any thing elfe, except pure charcoal, will be found in the retort. During the diftillation, there comes over a confiderable quantity of carbonic acid, and carbonated hydrogen gas*. Sugar therefore is decompofed by the action of heat; and the following compounds are formed from it: Water, pyromucous acid, oil, charcoal, carbonic acid, carbonated hydrogen gas. The quantity of oil is inconfiderable; by far the moft abundant product is pyromucous acid. Sugar indeed is very readily converted into pyromucous acid; for it makes its appearance always whenever fyrup is raifed to the boiling temperature. Hence the fmell of caromel, which fyrup at that temperature emits. Hence alfo the reafon that, when we attempt to cryftallize fyrup by heat, there always remains behind a quantity of incryftallizible matter, known by the name of *molaffes*; whereas if the fyrup be cryftallized without artificial heat, every particle of fugar may be obtained from it in a cryftalline form †. Hence we fee the importance of properly regulating the fire during the cryftallization of fugar, and the immenfe faving that would refult from conducting the operation at a low heat.

* Scopoli and Morveau, Enc. Meth. Chim. i. 269.

† Morveau. Enc. Meth. Chim. i. 266.

15 Its compofition. It follows from thefe facts, and from various other methods of decompofing fugar, that it is compofed of oxygen, hydrogen, and carbon; for all the fubftances obtained from fugar by diftillation may be refolved into thefe elements. Lavoifier has made it probable, by a feries of very delicate experiments, that thefe fubftances enter into the compofition of fugar in the following proportions:

64	oxygen,
28	carbon,
8	hydrogen.
100	

Of the way in which thefe ingredients are combined in fugar, we are ftill entirely ignorant. Lavoifier's conclufions can only be confidered as approximations to the truth.

Sugar is confidered as a very nourifhing article of food. It is found moft abundantly in the juice of the fugar cane, but many other plants alfo contain it. The juice of the acer faccharinum, or *fugar maple*, contains fo much of it, that in North America fugar is often extracted from that tree*. Sugar is alfo found in the roots of carrot, parfnip, beet, &c. Mr Achard has lately pointed out a method of increafing the quantity of fugar in beet fo much, that, according to his own account, it is at prefent cultivated in large quantities in Pruffia, and fugar extracted from it with advantage†. Parmentier has alfo afcertained that the grains of wheat, barley, &c. and all the other fimilar feeds which are ufed as food, contain at firft a large quantity of fugar, which gradually difappears as they approach to a ftate of maturity. This is the cafe alfo with peas and beans, and all leguminous feeds, and is one reafon why the flavour of young peas is fo much fuperior to that of old ones.

Starch. 16 Plants containing it.

* Rufh. Tranf. Phil. ad. iii. 64.

† Ann. de Chim. xxxii. 163.

SECT. II. *Of STARCH.*

17 Method of obtaining ftarch. WHEN a quantity of wheat flour is formed into a pafte, and water poured upon it till it runs off colourlefs, this water foon depofits a very fine whitifh powder; which, when properly wafhed and dried, is known by the name of *ftarch*. When firft prepared, it is of a grey colour; but the ftarchmakers render it white by fteeping it in water flightly acidulated. The acid feems to diffolve and carry off the impurities.

Starch was well known to the ancients. Pliny informs us, that the method of obtaining it was firft invented by the inhabitants of the ifland of Chio†.

† Lib. xviii. c. 7.

18 Its properties. Starch has a fine white colour, and is ufually concreted in longifh maffes; it has fcarcely any fmell, and very little tafte. When kept dry, it continues for a long time uninjured though expofed to the air.

19 How acted on by water. Starch does not diffolve in cold water, but very foon falls to powder. It combines with boiling water, and forms with it a thick pafte. Linen dipt into this pafte, and afterwards dried fuddenly, acquires, as is well known, a great degree of ftiffnefs. When this pafte is left expofed to damp air it foon lofes its confiftency, acquires an acid tafte, and its furface is covered with mould.

20 Alcohol. Starch is fo far from diffolving in alcohol, even when affifted by heat, that it does not even fall to powder.

21 Acids. When ftarch is thrown into any of the mineral acids, at firft no apparent change is vifible. But if an attempt is made to break the larger pieces while in acids to powder, they refift it, and feel exceedingly tough and adhefive. Sulphuric acid diffolves it flowly, and at the fame time a fmell of fulphurous acid is emitted, and fuch a quantity of charcoal is evolved, that the difh containing the mixture may be inverted without fpilling any of it. Indeed if the quantity of ftarch be fufficient, the mixture becomes perfectly folid. The charcoal may be feparated by dilution and filtration. In muriatic acid ftarch diffolves ftill more flowly. The folution refembles mucilage of gum arabic, and ftill retains the peculiar odour of muriatic acid. When allowed to ftand for fome time, the folution gradually feparates into two parts; a perfectly tranfparent ftraw-coloured liquid below, and a thick, muddy, oily, or rather mucilaginous fubftance, above. When water is poured in, the muriatic fmell inftantly difappears, and a ftrong fmell is exhaled, precifely fimilar to that which is felt in cornmills.

Gluten.

mills. Ammonia occasions a slight precipitate, but too small to be examined.

Nitric acid dissolves starch more rapidly than the other two acids; it acquires a green colour, and emits nitrous gas. The solution is never complete, nor do any crystals of oxalic acid appear unless heat be applied. In this respect starch differs from sugar, which yields oxalic acid with nitric acid, even at the temperature of the atmosphere. When heat is applied to the solution of starch in nitric acid, both oxalic and malic acid is formed, but the undissolved substance still remains. When separated by filtration, and afterwards edulcorated, this substance has the appearance of a thick oil, not unlike tallow; but it dissolves readily in alcohol. When distilled, it yields acetous acid, and an oil having the smell and the consistence of tallow*.

* *Scheele*, Crell's Jour. ii. 14. English translation.

22 Heat.

When starch is thrown upon a hot iron, it melts, blackens, froths, swells, and burns with a bright flame like sugar, emitting, at the same time, a great deal of smoke; but it does not explode, nor has it the caromel smell which distinguishes burning sugar. When distilled, it yields water impregnated with an acid, supposed to be the pyromucous, and mixed with a little empyreumatic oil. The charcoal which remains is easily dissipated when set on fire in the open air; a proof that it contains very little earth.

23 Its composition.

Barley grain consists almost entirely of starch, not however in a state of perfect purity. In the process of malting, which is nothing else than causing the barley to begin to vegetate, a great part of the starch is converted into sugar. During this process oxygen gas is absorbed, and carbonic acid gas is emitted. Water, too, is absolutely necessary; hence it is probable, that it is decomposed, and its hydrogen retained†. Starch, then, seems to be converted into sugar by diminishing the proportion of its carbon, and encreasing that of its hydrogen and oxygen. Its distillation shews us that it contains no other ingredients than these three.

† *Cruikshank, Rollo on Diabetes.*

24 Substances containing it.

Starch is contained in a great variety of vegetable substances; most commonly in their seeds or bulbous roots; but sometimes also in other parts. Mr Parmentier, whose experiments have greatly contributed towards an accurate knowledge of starch, has given us the following list of the plants from the roots of which it may be extracted.

Arctium lappa,	Imperatoria ostrutheum,
Atropa belladonna,	Hyoscyamus niger,
Polygonum bistorta,	Rumex obtusifolius,
Bryonia alba,	——— acutus,
Colchicum autumnale,	——— aquaticus,
Spiræa filipendula,	Arum maculatum,
Ranunculus bulbosus,	Orchis mascula,
Scrophularia nodosa,	Iris pseudacorus,
Sambucus ebulus,	— fœtidissima,
——— nigra,	Orobus tuberosus,
Orchis morio,	Bunium bulbocastanum.

It is found also nearly pure in the following seeds:

Oats,	Chesnut,	Acorn,
Rice,	Horsechesnut,	And also in
Maiz,	Peas,	Salop,
Millet,	Beans,	Sago.

SECT. III. *Of Gluten.*

WHEN wheat flour is washed in the manner described in the last section, in order to obtain starch from it, the substance which remains, after every thing has been washed away which cold water can separate, is called *gluten*. It was discovered by Beccaria an Italian philosopher, to whom we are indebted for the first analysis of wheat flour†.

25 Gluten, how obtained.

† *Collect. Acad.* x. 1.

26 Its properties.

Gluten, when thus obtained, is of a grey colour, exceedingly tenacious, ductile, and elastic, and may be extended to twenty times its original length. When very thin, it is of a whitish colour, and has a good deal of resemblance to animal tendon or membrane. In this state it adheres very tenaciously to other bodies, and has often been used to cement together broken pieces of porcelain. Its smell is agreeable. It has scarce any taste, and does not lose its tenacity in the mouth.

27 Action of air,

When exposed to the air, it gradually dries; and, when completely dry, it is pretty hard, brittle, slightly transparent, of a dark brown colour, and has some resemblance to *glue*. It breaks like a piece of glass, and the edges of the fracture resemble in smoothness those of broken glass; that is to say, it breaks with a *vitreous* fracture.

28 Water,

When exposed to the air, and kept moist, it soon putrifies; but when dry, it may be kept any length of time without alteration. It is insoluble in water; tho' it imbibes and retains a certain quantity of it with great obstinacy. To this water it owes its elasticity and tenacity. When boiled in water, it loses both these properties. It is soluble in alcohol, as Mr Vauquelin informs us‡; and precipitated again, as Mr Fourcroy has observed, by pouring into the alcohol two parts of water§.

‡ *Ann de Chim.* vi. 278.

§ *Ibid.* viii. 135.

29 Acids,

Gluten is soluble in the three mineral acids. When nitric acid is poured on it, and heat applied, there is a quantity of azotic gas emitted, as Berthollet discovered; and, by continuing the heat, a quantity of oxalic acid is formed||.

|| *Vauquelin, Ibid.* vi. 278.

30 Alkalies,

Alkalies dissolve gluten when they are assisted by heat. The solution is never perfectly transparent. Acids precipitate the gluten from alkalies, but it is destitute of its elasticity¶.

¶ *Fourcroy.*

31 Heat.

When moist gluten is suddenly dried, its swells amazingly. Dry gluten, when exposed to heat, cracks, swells, melts, blackens, exhales a fetid odour, and burns precisely like feathers or horn. When distilled, there comes over water impregnated with ammonia and an empyreumatic oil; the charcoal which remains is with difficulty reduced to ashes. From these phenumena, it is evident that gluten is composed of carbon, hydrogen, azot, and oxygen: perhaps also it contains a little lime. In what manner these substances are combined is unknown.

32 Its composition.

33 Substances containing it.

The only vegetable substance which has been hitherto found to contain it abundantly, is wheat flour. Vauquelin also found it in the fruit of the *cassia fistuloris**, and Fourcroy in the bark of a species of quinquina from St Domingo†. It probably exists in many other plants.

* *Ibid.*

† *Ibid.* viii. 135.

SECT. IV. *Of Albumen.*

Albumen.

IF the water in which wheat flour has been washed in order to obtain starch and gluten, according to the directions laid down in the two last sections, be filtrated, and afterwards boiled, a substance precipitates in white flakes; to which Mr Fourcroy, who first pointed it

Jelly. it out, has given the name of *albumen* (A), on account of its resemblance to the *white* of an egg ‡.

‡ Ann. de Chim. iii. 259.

34 Properties of albumen. It is evident, from the method of obtaining it, that albumen, in its natural state, is soluble in water, and that heat precipitates it from that fluid in a concrete state. While dissolved in water, it has scarcely any taste; but it has the property of changing vegetable blues, especially that which is obtained from the flowers of the mallow (*malva sylvestris*), into a green §. When allowed to remain dissolved in water, it putrifies without becoming previously acid ‖.

§ Fourcroy, Ibid. 257.

‖ Ibid.

After it has been precipitated from water in a concrete state by boiling, it is no longer soluble in water as before. Alcohol also precipitates it from water precisely in the same state as when it is precipitated by heat.

When concrete albumen is dried it becomes somewhat transparent, and very like glue. In that state it is soluble in alkalies, especially ammonia *.

* Ibid.

35 Its composition. When distilled it gives out carbonat of ammonia, a red fetid oil, and carbonated hydrogen gas; and a spongy charcoal remains behind †. From this, it is evident that albumen, like gluten, is composed of carbon, azot, hydrogen, and oxygen; but the proportions and combinations of these substances are altogether unknown.

† Ibid.

Mr Fourcroy found albumen in the expressed juice of scurvy grass, cresses, cabbage, and almost all cruciform plants. He found it, too, in a great many young and succulent plants; but never a particle in those parts of vegetables which contain an acid. He observed also that the quantity decreased constantly with the age of the plant.

SECT. V. *Of Jelly.*

If we press out the juice of ripe blackberries, currants, and many other fruits, and allow it to remain for some time in a state of rest, it partly coagulates into a tremulous soft substance, well known by the name of *jelly*. If we pour off the uncoagulated part, and wash the coagulum with a small quantity of water, we obtain *jelly* approaching to a state of purity.

36 Properties of jelly. In this state it is nearly colourless, unless tinged by the peculiar colouring matter of the fruit; it has a pleasant taste, and a tremulous consistency. It is scarcely soluble in cold water, but very soluble in hot water; and, when the solution cools, it again coagulates into the form of a jelly †. When long boiled, it loses the property of gelatinising by cooling, and becomes analagous to mucilage ‡. This is the reason that in making currant jelly, or any other jelly, when the quantity of sugar added is not sufficient to absorb all the watery parts of the fruit, and consequently it is necessary to concentrate the liquid by long boiling, the mixture often loses the property of coagulating, and the jelly, of course, is spoiled. §.

† Vauquelin, Ann. de Chim. vi. 282.

‡ Id. Ibid. v. 100.

Gum.

§ Ann. de Chim. v. 102.

Jelly combines readily with alkalies; nitric acid converts it into oxalic acid, without separating any azotic gas ‖. When dried it becomes transparent ¶. When distilled it affords a great deal of pyromucous acid, a small quantity of oil, and scarcely any ammonia †.

‖ Ibid. vi. 282.

¶ Ibid. v. 100.

† Ibid. vi. 286.

Jelly exists in all acid fruits, as oranges, lemons, gooseberries, &c. and no albumen is ever found in those parts of vegetables which contain an acid. This circumstance has induced Fourcroy to suppose that jelly is albumen combined with an acid *: but this conjecture has not been verified by experiment; nor indeed is it probable that it ever shall; as albumen evidently contains a quantity of azot, and jelly scarcely any. The products of jelly by distillation shew that it approaches nearer than any other vegetable substance to the nature of sugar.

* Ibid. iii. 261.

SECT. VI. *Of Gum.*

37 Gum how obtained. There is a thick transparent tastelefs fluid which sometimes exsudes from certain species of trees. It is very adhesive, and gradually hardens without losing its transparency; but easily softens again when moistened with water. This exsudation is known by the name of *gum*. The gum most commonly used is that which exsudes from different species of the *mimosa*, particularly the *nilotica* †. It is known by the name of *gum arabic*. Gum likewise exsudes abundantly from the *prunus avium* or common wild cherry tree of this country.

† Shousbar, Phil. Mag. v. 241.

Gum is usually obtained in small pieces like tears, moderately hard, and somewhat brittle while cold, so that it can be reduced by pounding to a fine powder. Its colour is usually yellowish, and it is not destitute of lustre. It has no smell; its taste is insipid.

38 Action of water. Gum undergoes no change from being exposed to the atmosphere; but the light of the sun makes it assume a white colour. Water dissolves it in large quantities. The solution which is known by the name of *mucilage* (B), is thick and adhesive: it is often used as a paste, and to give stiffness and lustre to linen. When spread out thin it soon dries, and has the appearance of a varnish; but it readily attracts moisture, and becomes glutinous. Water washes it away entirely. When mucilage is evaporated the gum is obtained unaltered.

39 Alcohol. Gum is insoluble in alcohol. When alcohol is poured into mucilage, the gum immediately precipitates; because the affinity between water and alcohol is greater than that between water and gum.

The action of alkalies and earths upon gum has not been

(A) The existence of albumen in vegetables was known to Scheele. He mentions it particularly in his paper on Milk, first published in the year 1780. See *Scheele's Works*, II. 55. Dijon edition.

(B) Hermstadt uses this word in a different sense. He makes a distinction between *gum* and *mucilage*. The solution of *gum* in water is transparent and glutinous, and can be drawn out into threads; whereas that of *mucilage* is opake, does not feel glutinous, but slippery, and cannot be drawn into threads. Gum may be separated from mucilage by the following process:

Let the gum which is supposed to be mixed with mucilage, previously reduced to a dry mass, be dissolved in as small a quantity of water as possible, and into the solution drop at intervals diluted sulphuric acid. The mucilage coagulates while the gum remains dissolved. When no more coagulation takes place, let the mixture remain at rest for some time, and the mucilage will precipitate to the bottom, and assume the consistence of jelly. Decant off the liquid part, and evaporate the mucilage to dryness by a gentle heat till it acquires the consistence of horn. *Med. and Phys. Jour.* iii. 370.

Extract. been examined. Acids do not precipitate it from mucilage ‡. The concentrated mineral acids destroy it. Concentrated sulphuric acid decomposes it; water is formed, and perhaps also acetous acid; while charcoal is precipitated. Nitric acid converts it into oxalic acid; oxy-muriatic acid, on the contrary, into citric acid *.

‡ Vauquelin.

* Id. Ann. de Chim. vi. 78.

40 Of heat. When gum is exposed to heat it softens and swells, but does not melt; it emits air bubbles, blackens, and at last, when nearly reduced to charcoal, emits a low blue flame. This flame appears sooner if a flaming substance be held just above the gum. After the gum is consumed, there remains a small quantity of white ashes, composed chiefly of the carbonats of lime and potash.

When gum is distilled in a retort, the products are water impregnated with a considerable quantity of pyromucous acid, a little empyreumatic oil, carbonic acid gas, and carbonated hydrogen gas. When the pyromucous acid obtained by this process is saturated with lime, a quantity of ammonia is disengaged with which that acid had been combined. The charcoal which remained in the retort leaves behind it, after incineration, a little lime, and phosphat of lime §.

§ Cruikshank, Rollo on Diabetes.

41 Its composition. These experiments shew us that gum is composed of hydrogen, carbon, oxygen, azot, lime, and phosphorus; but the proportions and combinations of these substances are unknown to us. Mr Cruickshank has rendered it probable that the quantity of carbon is greater, and the quantity of oxyen less, in gum than in sugar ||.

|| Ibid.

Gum, or mucilage, exists most abundantly in young plants, and gradually disappears as they arrive at perfection. It forms a great proportion of the leaves and roots of many eatable plants.

SECT. VII. *Of Extract*.

THE word *extract* was at first applied to all those substances which were extracted from plants by means of water, and consequently included gum, jelly, and several other bodies. But of late it has been confined, by those chemists who have paid attention to the use of language, to a substance which exists in many plants, and which may be obtained by infusing *saffron* in water for some time, filtrating the infusion, and evaporating it to dryness. The residuum, after evaporation, is *extract* nearly pure ¶. It possesses the following properties:

42 Extract, how obtained.

¶ Hermstadt.

43 Its properties. Water dissolves it in considerable quantities, especially hot water. Alcohol also dissolves it with facility. This property of being soluble both in water and alcohol has induced some chemists to give *extract* the name of *soap*. It is insoluble in sulphuric ether. These three properties are sufficient to distinguish it from every other vegetable substance *.

* Hermstadt.

When the solution of extract in water is exposed for some time in the open air, the extract precipitates, and is now no longer soluble in water. This change is supposed to proceed from the addition of a quantity of oxygen which it imbibes from the atmosphere †.

† Fourcroy.

When oxy-muriatic acid is poured into a watery solution of extract, that substance precipitates in yellow flakes. These flakes are insoluble in water; they are insoluble also in alcohol at the temperature of 97°; but that liquid dissolves them at the temperature of 120°. They are soluble also in alkalies, and in boiling-hot water they melt into a yellow mass ‡.

‡ Fourcroy.

Extract is soluble in acids. Heat softens but does not melt it §.

Tan.

§ Id. Ann. de Chim. viii.

It is found in a great variety of plants; but as no method of obtaining it perfectly pure has hitherto been discovered, the extracts of different plants differ somewhat from each other both in their colour and smell.

SECT. VIII. *Of Tan*.

44 Preparation of tan. IF a quantity of nut galls, coarsely powdered, be kept for some time infused in cold water, if the water be filtered, and a solution of muriat of tin be dropt into it, a copious white precipitate falls to the bottom. This precipitate is to be carefully washed and diffused (for it will not dissolve) thro' a large quantity of water, and this water is to be saturated with sulphurated hydrogen gas so completely that it will not absorb any more. By this treatment the white precipitate will gradually disappear, and a brown precipitate will take its place. This brown precipitate must be separated by filtration; and the water, which has now acquired the colour and the taste of the infusion of nut galls, must be evaporated to dryness. A substance remains behind, known by the name of *tan* or *tannine*.

It was first discovered by Seguin, who pointed out some of its properties, and the method of detecting it in plants ||. The above method of obtaining it in a state of purity was contrived by Mr Proust. Tan exists in the solution of nut galls combined with gallic acid. The oxyd of tin has a strong affinity for it. When muriat of tin is poured in, the tan combines with the oxide, and the compound, being insoluble, falls to the bottom. Sulphur has a stronger affinity for the oxide than tan has. Hence when sulphurated hydrogen gas is thrown upon this compound, the sulphur leaves the gas and combines with the tin; and the compound, being insoluble, falls to the bottom: The hydrogen gas escapes, and nothing remains in the water except the tan.

|| Nicholson's Jour. i. 271.

45 Its properties. Tan is a brittle substance, of a brown colour. It breaks with a vitreous fracture, and does not attract moisture from the air. Its taste is exceedingly astringent. It is very soluble in water. The solution is of a deep brown colour, a very astringent and bitter taste, and has the odour which distinguishes a solution of nut galls. It froths, when agitated, like a solution of soap; but does not feel unctuous. Acids precipitate the tan from this solution.

Tan is still more soluble in alcohol than in water.

When the solution of tan is poured into a solution of the brown sulphat of iron, a deep blue coloured precipitate immediately appears, consisting of the tan combined with the oxide. This precipitate, when dried, assumes a black colour. It is decomposed by acids. The green sulphat of iron is not altered by tan.

When too great a proportion of brown sulphat of iron is poured into a solution of tan, the sulphuric acid, set at liberty by the combination of the iron and tan, is sufficient to redissolve the precipitate as it appears; but the precipitate may easily be obtained by cautiously saturating this excess of acid with potash. When the experiment is performed in this manner, all the red sulphat of iron which remains in the solution undecomposed is converted into green sulphat. Mr Proust, to whom we are indebted for almost every thing yet known concerning the properties of tan, supposes that this change is produced

Camphor.

produced by the tan absorbing oxygen from the iron. This may very possibly be the case; but his experiments are insufficient to prove that it is. The same change takes place if red oxide be mixed with a considerable excess of sulphuric acid, and diluted with water.

Tan combines readily with oxygen. When oxy-muriatic acid is poured upon it, its colour deepens, and it loses all its peculiar characters *.

* Proust, Ann. de Chim. xxv. 225.

46 Plants containing it.

Tan exists in almost all those vegetable substances which have an astringent taste. It is almost constantly combined with gallic acid. The following table, drawn up by Mr Biggin †, though the rule which the author followed in making his experiments precluded rigid accuracy, will serve to give some idea of the proportions of tan which exist in different plants:

† Phil. Trans. 1799.

	Prop. of Tan.		Prop. of Tan.
Elm - -	2,1	Sallow - -	4,6
Oak cut in winter -	2,1	Mountain ash -	4,7
Horse chesnut -	2,2	Poplar - -	6,0
Beech - -	2,4	Hazel - -	6,3
Willow (boughs) -	2,4	Ash - - -	6,6
Elder - -	3,0	Spanish chesnut -	9,0
Plum tree - - -	4,0	Smooth oak - -	9,2
Willow (trunk) -	4,0	Oak cut in spring	9,6
Sycamore - -	4,1	Huntingdon or Leicester willow	10,1
Birch - -	4,1		
Cherry tree - -	4,2	Sumach - -	16,2

Sect. IX. *Of Oils.*

There are two species of oils; namely, *fixed* and *volatile*: both of which are found abundantly in plants.

1. Fixed oil is found in the seeds of many plants, especially of the oil, beech, flax, almond, rape, &c.

2. Volatile oil is obtained by distillation from the leaves, flowers, or roots of aromatic plants, as lavender, roses, rosemary, &c.

As an account of the properties of oils has been given already in the article Chemistry, *Suppl.* it would be superfluous to repeat it here.

Sect. X. *Of Camphor.*

The laurus camphorata is a tree which grows in China, Japan, and several parts of India. When the roots of this tree are put into an iron pot furnished with a capital, and a sufficient heat is applied, a particular substance sublimes into the capital, which is known by the name of *camphor*. The Dutch afterwards purify this camphor by a second sublimation.

Camphor is a white brittle substance, having a peculiar aromatic odour and a strong taste.

47 Properties of camphor.

It is not altered by atmospheric air; but it is so volatile, that if it be exposed during warm weather in an open vessel, it evaporates completely. When sublimed in close vessels it crystallises in hexagonal plates or pyramids *.

* Romieu.

It is insoluble in water; but it communicates to that liquid a certain portion of its peculiar odour.

It dissolves readily in alcohol, and is precipitated again by water. If the alcohol be diluted with water as much as possible, without causing the camphor to precipitate, small crystals of camphor resembling feathers gradually form †.

† Romieu, Mem. Par. 1756, p. 41.

Camphor is soluble also in hot oils, both fixed and volatile; but as the solution cools the camphor precipitates, and assumes the form of plumose, or feather-like crystals ‡.

‡ Romieu, Mem. Par. 1756, p. 41.

Camphor is not acted on by alkalies, either pure or in the state of carbonats. Pure alkalies indeed seem to dissolve a little camphor; but the quantity is too small to be perceptible by any other quality than its odour §. Neither is it acted upon by any of the neutral salts which have hitherto been tried.

§ Bouillon, la Grange, Ann. de Chim. xxiii. 154.

Acids dissolve camphor, but it is precipitated again, unaltered, by alkalies, and even by water. The solution of camphor in sulphuric acid is red; that in the nitric acid is yellow. This last solution has obtained the absurd name of *oil of camphor*. When nitric acid is distilled repeatedly off camphor, it converts it into camphoric acid.

Muriatic, sulphurous, and fluoric acids, in the state of gas, dissolve camphor. When water is added, the camphor appears unaltered in flakes, which swim on the surface of the water §.

§ Fourcroy.

When heat is applied to camphor it is volatilized. If the heat be sudden and strong, the camphor melts before it evaporates. It catches flame very readily, and emits a great deal of smoke as it burns, but it leaves no residuum. It is so inflammable that it continues to burn even on the surface of water. When camphor is set on fire in a large glass globe filled with oxygen gas, and containing a little water, it burns with a very bright flame, and produces a great deal of heat. The inner surface of the glass is soon covered with a black powder, which has all the properties of charcoal, a quantity of carbonic acid gas is evolved, the water in the globe acquires a strong smell, and is impregnated with carbonic acid and camphoric acid ‖.

‖ Bouillon la Grange, ibid. p. 168.

48 Its analysis.

If two parts of alumina and one of camphor be formed into a paste with water, and distilled in a glass retort, there comes over into the receiver (which should contain a little water, and communicate with a pneumatic apparatus) a volatile oil of a golden yellow colour, a little camphoric acid which dissolves in the water, and a quantity of carbonic acid gas, and carbonated hydrogen gas, which may be collected by means of a pneumatic apparatus. There remains in the retort a substance of a deep black colour, composed of alumina and charcoal. By this process, from 122.284 parts of camphor, Mr Bouillon la Grange, to whom we are indebted for the whole of the analysis of camphor, obtained 45.856 parts of volatile oil, and 30.571 parts of charcoal. The proportion of the other products was not ascertained *.

* Ibid. p. 157.

From this analysis, Mr Bouillon la Grange concludes that camphor is composed of volatile oil, and charcoal or carbon, combined together. We learn from his experiments, that the ultimate ingredients of camphor are carbon and hydrogen; and that the proportion of carbon is much greater than in oils.

49 Plants containing it.

Camphor exists in a great many plants. Neumann, Geoffroy, and Cartheuser, extracted it from the roots of zedoary, thyme, sage, &c. and rendered it probable that it is contained in almost all the labiated plants. It has been supposed to exist in these plants combined with volatile oil. Proust has shewn how it may be extracted, in considerable quantity, from many volatile oils †.

† Ann. de Chim. iv. 179.

Camphor, which was unknown to the ancient Greeks and Romans, was introduced into Europe by the Arabians.

Resins. bians. Ætius is the first person who mentions it. It seems, however, to have been very early known to the eastern nations.

It is much used in medicine. It is a powerful stimulant; it is considered as peculiarly efficacious in diseases of the urinary organs; it is often serviceable in mania, and procures sleep when every other medicine fails.

SECT. XI. *Of Resins.*

THERE is a yellowish white coloured substance which often exsudes from the *Abies Montana*, or *common Scotch fir*, and likewise from other fir trees. It is somewhat transparent, is hard and brittle, of a disagreeable taste, and may be collected in considerable quantities. This substance is known by the name of *resin*; and the same name is also applied to all substances which possess nearly the same properties with it. Resin may be distinguished from every other substance by the following properties:

50 Properties of resin. It is more or less concrete, and has an acrid and hot taste.

It is totally insoluble in water. By this property it may easily be separated from gum, if they happen to be mixed together.

It is soluble in alcohol, and in sulphuric ether *. By the first of these properties we may separate it from gum, and by the last from extract; for extract is insoluble in sulphuric ether. When these solutions are evaporated the resin is obtained unaltered. If the solution be spread thin upon any body, it soon dries by the evaporation of the alcohol; the resin remains behind, and covers the body with a smooth shining transparent coat, which cannot be washed off by water. This process is called *varnishing*.

Resin is soluble also in volatile oils; and these solutions are often used likewise in varnishing.

Resin is scarcely acted upon by acids. Alkalies combine with it, but the combination is not easily effected.

When resin is heated it readily melts; and if the heat be increased it is volatilized, and burns with a white flame and strong smell. When distilled it yields much volatile oil, but scarcely any acid.

When volatile oils are exposed for some time to the action of the atmosphere they acquire consistency, and assume the properties of resins. During this change they absorb a quantity of oxygen from the air. Westrum put 30 grains of oil of turpentine into 40 cubic inches of oxy-muriatic acid gas. Heat was evolved, the oil gradually evaporated, and assumed the form of yellow resin †. These facts render it probable that resin is merely volatile oil combined with a quantity of oxygen.

To know whether any vegetable substance contains resin, we have only to pour some sulphuric ether upon it in powder, and expose the infusion to the light. If any resin be present the ether will assume a brown colour ‡.

51 Number of resins. The number of resins is considerable. They differ from each other chiefly in colour, taste, smell, and consistency. Whether these resins be really different combinations, or, as is most likely, owe these differences to foreign ingredients, either combined with the resin, or mechanically mixed with it, is not at present known. To describe each resin separately would be to little purpose, as scarcely any thing is known of them except their general properties as resins. The following is a list of the principal. The reader will find an account of the manner of obtaining them, and of their uses, by consulting the name of each in the *Encyclopædia*.

1. Common resin,	7. Sandarac,
2. Turpentine,	8. Guiacum,
3. Pitch,	9. Labdanum,
4. Galipot,	10. Dragon's blood,
5. Elemi,	11. Copaiba.
6. Mastic,	

52 Balsams. There are three vegetable substances which have been denominated *balsams* by some of the later French writers. They appear to consist of resin, or volatile oil combined with benzoic acid. These substances are, benzoin, balsam of Tolu, and storax. For an account of them we refer to the *Encyclopædia*.

53 Gum resins. Many vegetable substances occur in medicine which consist chiefly of a mixture of gum and resin. These substances, of course, have a number of the properties both of gums and resins. For this reason they have been denominated *gum resins*. The following are the most important of these substances:

Olibanum,	Aloes,
Galbanum,	Myrrh,
Scammony,	Ammoniac,
Asafœtida,	Opium.

For an account of them we refer to the *Encyclopædia*.

SECT. XII. *Of Caoutchouc.*

54 Discovery of caoutchouc. ABOUT the beginning of the 18th century a substance, called *caoutchouc*, was brought as a curiosity from America. It was soft, wonderfully elastic, and very combustible. The pieces of it that came to Europe were usually in the shape of bottles, birds, &c. This substance is very much used in rubbing out the marks made upon paper by a black lead pencil; and therefore in this country it is often called *Indian rubber*. Nothing was known of its production, except that it was obtained from a tree, till the French academicians went to South America in 1735 to measure a degree of the meridian. Mr de la Condamine sent an account of it to the French Academy in the year 1736. He told them, that there grew in the province of Esmeraldas, in Brazil, a tree, called by the natives *Hhevé*; that from this tree there flowed a milky juice, which, when inspissated, was *caoutchouc*. Don Pedro Maldonado, who accompanied the French academicians, found the same tree on the banks of the Maragnon; but he died soon after, and his papers were never published. Mr Fresnau, after a very laborious search, discovered the same tree in Cayenne. His account of it was read to the French Academy in 1751.

55 Plants containing it. It is now known that there are at least two trees in South America from which caoutchouc may be obtained, the Hævea Caoutchouc and the Jatropha Elastica; and it is exceedingly probable that it is extracted also from other species of Hævea and Jatropha. Several trees likewise which grow in the East Indies yield caoutchouc; the principal of these are, the Ficus Indica, the Artocarpus Integrifolia, and the Urceola Elastica; a plant discovered by Mr Howison, and first described and named by Dr Roxburgh *.

* Hermstadt.
† Crell's Annals, i. 90.
‡ Hermstadt.
* Asiatic Researches, v. 167. London edition.

Caoutchouc.

When any of theſe plants is punctured, there exſudes from it a milky juice, which, when expoſed to the air, gradually lets fall a concrete ſubſtance, which is caoutchouc.

If oxy-muriatic acid be poured into the milky juice, the caoutchouc precipitates immediately, and, at the ſame time, the acid loſes its peculiar odour. This renders it probable that the formation of the caoutchouc is owing to its baſis abſorbing oxygen *. If the milky juice be confined in a glaſs veſſel containing common air, it gradually abſorbs oxgen, and a pellicle of caoutchouc appears on its ſurface †.

* Fourcroy, Ann. de Chim. xi. 229.
† Ibid.

56
Properties of caoutchouc.

Caoutchouc was no ſooner known than it drew the attention of philoſophers. Its ſingular properties promiſed that it would be exceedingly uſeful in the arts, provided any method could be fallen upon to mould it into the various inſtruments for which it ſeemed peculiarly adapted. Meſſrs de la Coudimine and Freſnau had mentioned ſome of its properties; but Macquer was the firſt perſon who undertook to examine it with attention. His experiments were publiſhed in the memoirs of the French Academy for the year 1768. They threw a good deal of light on the ſubject; but Macquer fell into ſome miſtakes, which were pointed out by Mr Berniard, who publiſhed an admirable paper on caoutchouc in the 17th volume of the *Journal de Phyſique*. To this paper we are indebted for the greater number of facts at preſent known reſpecting caoutchouc. Mr Groſſart and Mr Fourcroy have likewiſe added conſiderably to our knowledge of this ſingular ſubſtance; both of their treatiſes have been publiſhed in the 11th volume of the *Annales de Chemie*.

Caoutchouc, when pure, is of a white colour (c), and without either taſte or ſmell ‡. The blackiſh colour of the caoutchouc of commerce is owing to the method employed in drying it after it has been ſpread upon moulds. The uſual way is to ſpread a thin coat of the milky juice upon the mould, and then to dry it by expoſing it to ſmoke; afterwards another coat is ſpread on, which is dried in the ſame way. Thus the caoutchouc of commerce conſiſts of numerous layers of pure caoutchouc alternating with as many layers of ſoot.

‡ Fourcroy, ibid. 232.

Caoutchouc is ſoft and pliable like leather. It is exceedingly elaſtic and adheſive; ſo that it may be forcibly ſtretched out much beyond its uſual length, and inſtantly recover its former bulk when the force is withdrawn. It cannot be broken without very conſiderable force.

57
Action of water,

It is not altered by expoſure to the air; it is perfectly inſoluble in water: but if boiled for ſome time its edges become ſomewhat tranſparent, owing undoubtedly to the water carrying off the ſoot; and ſo ſoft, that when two of them are preſſed and kept together for ſome time, they adhere as cloſely as if they formed one piece. By this contrivance pieces of caoutchouc may be ſoldered together, and thus made to aſſume whatever ſhape we pleaſe §.

§ Groſſart, Ann. de Chim. xi. 133.

58
Alcohol,

Caoutchouc is inſoluble in alcohol. This property was diſcovered very early, and fully confirmed by the experiments of Mr Macquer. The alcohol, however, renders it colourleſs.

59
Ether,

Caoutchouc is ſoluble in ether. This property was firſt pointed out by Macquer. Berniard, on the contrary, found that caoutchouc was ſcarcely ſoluble at all in ſulphuric ether, which was the ether uſed by Macquer, and that even nitric ether was but an imperfect ſolvent. The difference in the reſults of theſe two chemiſts was very ſingular; both were remarkable for their accuracy, and both were too well acquainted with the ſubject to be eaſily miſled. The matter was firſt cleared up by Mr Cavallo. He found that ether, when newly prepared, ſeldom or never diſſolved caoutchouc completely; but if the precaution was taken to waſh the ether previouſly in water, it afterwards diſſolved caoutchouc with facility. Mr Groſſart tried this experiment, and found it accurate *. It is evident from this that theſe chemiſts had employed ether in different ſtates. The waſhing of ether has two effects. It deprives it of a little acid with which it is often impregnated, and it adds to it about one-tenth of water, which remains combined with it.

* Ann. de Chim. xi. 147.

When the ether is evaporated, the caoutchouc is obtained unaltered. Caoutchouc, therefore, diſſolved in ether, may be employed to make inſtruments of different kinds, juſt as the milky juice of the hævea; but this method would be a great deal too expenſive for common uſe.

60
Oils,

Caoutchouc is ſoluble in volatile oils †; but, in general, when theſe oils are evaporated, it remains ſomewhat glutinous, and therefore is ſcarcely proper for thoſe uſes to which, before its ſolution, it was ſo admirably adapted.

† Berniard.

61
Acids and alkalies,

It is inſoluble in alkalies ‡. The acids act upon it with more or leſs violence according to their nature. Sulphuric acid decompoſes it completely, charcoal precipitates, and part of the acid is converted into ſulphurous acid. Nitric acid converts it into a yellow ſubſtance, analogous to ſuberic acid. Muriatic acid does not affect it §. The other acids have not been tried.

‡ Id.
§ Id.

Fabroni has diſcovered, that rectified petroleum diſſolves it, and leaves it unaltered when evaporated ‖.

‖ Ibid. 195. and xii. 156

62
Heat.

When expoſed to heat it readily melts; but it never afterwards recovers its properties, but continues always of the conſiſtence of tar. It burns very readily with a bright white flame, and diffuſes a fetid odour. In thoſe countries where it is produced, it is often uſed by way of candle.

When diſtilled, it gives out ammonia ¶. It is evident from this, and from the effect of ſulphuric and nitric acid upon it, that it is compoſed of carbon, hydrogen, azot, and oxygen; but the manner in which they are combined is unknown.

¶ Fourcroy, Ann. de Chim. xi. 232.

When treated with nitric acid, there came over azotic gas, carbonic acid gas, pruſſic acid gas; and oxalic acid was formed *.

* Ibid.

63
How to ſeparate it from plants

It ſeems to exiſt in a great variety of plants; but is uſually confounded with the other ingredients. It may be ſeparated from reſins by means of alcohol. It may be extracted from the different ſpecies of *miſletoe* by water, with which, in the fluid ſtate in which it exiſts in theſe plants, it readily combines. When mixed with gum or extract, it may be ſeparated by the following proceſs: Digeſt a part of the plant containing it firſt in water and then in alcohol, till all the ſubſtances ſoluble

(c) Mr De Fourcroy ſays, that blackiſh brown is the natural colour of caoutchouc. But we have ſeen ſome pieces of it from the Eaſt Indies, which had been allowed to inſpiſſate in the open air: They were white, with a ſlight caſt of yellow, and had very much the appearance and feel of white ſoap.

Wax.

luble in these liquids be extracted. Dry the residuum, and digest it in five times its weight of rectified petroleum. Express the liquid part by squeezing the substance in a linen cloth. Let this liquid remain several days to settle, then decant off the clear liquid part, mix it with a third part of water and distil, the caoutchouc remains behind *.

* Hermstadt, Med. and Phys Jour. ii. 372.

SECT. XIII. *Of Wax.*

THE upper surface of the leaves of many trees is covered with a varnish of wax. This varnish may be separated and obtained in a state of purity by the following process.

64 Wax a vegetable production.

Digest the bruised leaves, first in water and then in alcohol, till every part of them which is soluble in these liquids be extracted. Then mix the residuum with six times its weight of a solution of pure ammonia, and, after sufficient maceration, decant off the solution, filter it, and drop into it, while it is incessantly stirred, diluted sulphuric acid, till more be added than is sufficient to saturate the alkali. The wax precipitates in the form of a yellow powder. It should be carefully washed with water, and then melted over a gentle fire †.

Mr Tingry first discovered that this varnish possessed all the properties of *bees wax* ‡. Wax then is a vegetable product. The bees extract it unaltered from the leaves of trees and other vegetable substances which contain it. They seem, however, to mix it with some of the pollen of flowers.

† Id. ibid. 373.

‡ Enc. Meth. Forets et Bois, i. 100.

65 Its properties.

Wax, when pure, is of a whitish colour, it is destitute of taste, and has scarcely any smell. Bees wax indeed has a pretty strong aromatic smell; but this seems chiefly owing to some substance with which it is mixed; for it disappears almost completely by exposing the wax, drawn out into thin ribands, for some time to the atmosphere. By this process also, which is called *bleaching*, the yellow colour of the wax disappears, and it becomes very white. Bleached wax is not affected by the air §.

Wax is insoluble in water and in alcohol. It combines readily with alkalies, and forms with them a soap which is soluble in water ||.

Punic wax, which the ancients employed in painting in encausto, is a soap composed of twenty parts of wax and one of soda *. Its composition was ascertained by Mr Lorgna †.

§ Senebier, Ann. de Chim xii. 60. and Jour. de Phys. xxxviii. 56.

|| Chaptal, iii. 164.

* Plin. l. 21. c. 14.

† Jour de Phys. Nov. 1785.

Sulphuric and nitric acids decompose wax completely; oxy-muriatic acid bleaches it instantaneously.

Wax combines readily with oils, and forms with them a substance of greater or less consistency according to the quantity of oil. This composition, which is known by the name of *cerate*, is much employed by surgeons.

When heat is applied to wax it becomes soft; and at the temperature of 142°, if unbleached, or of 155° if bleached ‡, it melts into a colourless transparent fluid, which concretes again, and resumes its former appearance as the temperature diminishes. If the heat be still farther increased, the wax boils and evaporates; and if a red heat be applied to the vapour, it takes fire and burns with a bright flame. It is this property which renders wax so useful for making candles.

‡ Nicholson's Journal, i. 71.

66 Analysis.

Mr Lavoisier, by means of the apparatus described in the article CHEMISTRY, *Suppl.* nº 353. contrived to burn wax in oxygen gas. The quantity of wax consumed was 21.9 grains. The oxygen gas employed in consuming that quantity amounted to 66.55 grains. Consequently the substances consumed amounted to 88.45 grains. After the combustion there were found in the glass vessel 62.58 grains of carbonic acid, and a quantity of water, which was supposed to amount to 25.87 grains. These were the only products.

Now 62.58 grains of carbonic acid gas contain

44.56 of oxy. and 18.02 of carb; and 25.87 gr. of water contain
21.99 of oxy. and 3.88 of hydro.

66.55	21.90

Consequently 21.9 parts of wax are composed of 18.02 of carbon, and 3.88 of hydrogen. And 100 parts of wax are composed of

82.28 carbon,
17.72 hydrogen,

100.00 *

* Lavoisier, Jour. de Phys. xxxi. 59.

If wax be distilled with a heat greater than 212°, there comes over a little water, some sebacic acid, a little very fluid and odorous oil: the oil, as the distillation advances, becomes thicker and thicker, till at last it is of the consistency of butter, and for this reason has been called *butter of wax*. There remains in the retort a small quantity of coal, which is not easily reduced to ashes. When the butter of wax is repeatedly distilled it becomes very fluid, and assumes the properties of volatile oil †.

† Lemery, Mem. Par. 1708. p. 53.

Woody Fibre.

SECT. XIV. *Of the WOODY FIBRE.*

ALL trees, and most other plants, contain a particular substance, well known by the name of *wood*. If a piece of wood be well dried, and digested, first in a sufficient quantity of water, and then of alcohol, to extract from it all the substances soluble in these liquids, there remains behind only the *woody fibre*.

67 Properties of wood.

This substance, which constitutes the basis of wood, is composed of longitudinal fibres, easily subdivided into a number of smaller fibres. It is somewhat transparent; is perfectly tasteless; has no smell; and is not altered by exposure to the atmosphere.

It is insoluble in water and in alcohol; but soluble in alkalies. The mineral acids decompose it. When distilled it yields, in all probability, pyrolignous acid. When burnt with a smothered fire it leaves behind it a considerable quantity of charcoal.

It is precipitated from alkalies unaltered by acids ‡.

‡ Fourcroy, Ann. de Chim. viii. 149.

68 Its analysis.

By nitric acid Fourcroy converted the residuum of quinquina, which does not seem to differ from the woody fibre, into oxalic acid; at the same time there was a little citric acid formed, and a very small quantity of malic and acetous acids. Some azotic gas also was disengaged. By this process he obtained from 100 parts of woody fibre

56.250 oxalic acid,
3.905 citric acid,
0.388 malic acid,
0.486 acetous acid,
0.867 azotic gas,
8.330 carbonat of lime.

70.226
32.031 residuum.

102.257

There was likewise a quantity of carbonic acid gas disengaged, the weight of which was unknown. This

increase

Acids.

increaſe of weight in the product was evidently owing to the oxygen derived from the nitric acid*.

* Ann. de Chim. viii. 153.

When diſtilled in a retort, 100 parts yield the following products:

26.62 of a yellow liquid, containing alcohol, and acid which had the ſmell of pyromucous.

6.977 of concrete oil, moſtly ſoluble in alcohol.

22.995 charcoal } in the retort.
3.567 carbonat of lime }

60.159

39.841 gas, half carbonic acid, half carbonated hydrogen.

100.000*.

* Ibid. 151.

Theſe facts ſhew us, that the woody fibre is compoſed of oxygen, carbon, hydrogen, azot, and lime. Mr Chaptal ſuppoſes that mucilage differs from woody fibre merely in containing leſs oxygen. We are certain at leaſt that mucilage or gum is compoſed of the ſame ingredients; and Mr Chaptal has ſhewn, that the juices of plants are partly converted into woody fibre by oxy-muriatic acid, which imparts to them oxygen†. Theſe juices contain both gum and reſin: after the formation of the woody fibre the reſin is ſtill unaltered. This gives a good deal of probability to his opinion.

† Ibid. xxi. 285.

SECT. XV. *Of Acids.*

THE acids found ready formed in vegetables are the following:

1. Oxalic,	5. Gallic,
2. Tartarous,	6. Benzoic,
3. Citric,	7. Phoſphoric.
4. Malic,	

Sometimes alſo the ſulphuric, nitric, and muriatic acids occur in vegetables, combined with alkalies or earths, but never except in very minute quantities.

69
Plants containing oxalic acid.

1. Oxalic acid is eaſily detected and diſtinguiſhed by the following properties: It decompoſes all calcareous ſalts, and forms with lime a ſalt inſoluble in water. It readily cryſtallizes. Its cryſtals are quadrilateral priſms. It is totally deſtroyed by heat.

Oxalic acid was firſt detected in vegetables by Mr Scheele. It has been diſcovered in the following plants:

The leaves of the oxalis acetoſella†.
oxalis corniculata.
The root of rhubarb‡.
The leaves of the geranium acidum§.

† Scheele, Crell's Jour. i. 107. Engl. Tranſl.
‡ Ibid. 34.
§ Hermſtadt.

70
Tartarous acid,

2. Tartarous acid is known by the following properties: When a little potaſs is cautiouſly dropt into a ſolution containing it, common tartar is formed, and precipitates to the bottom. Tartarous acid does not decompoſe the ſulphat, nitrat, or muriat of lime. Tartrite of lime is ſoluble in water. Tartarous acid cryſtallizes. Its cryſtals are long ſlender priſms. It is deſtroyed by heat.

Tartarous acid has been found in the following vegetable ſubſtances:

The pulp of the tamarind*.
The juice of grapes.
Mulberries†.
Rumex acetoſa, *ſorrel*†.
Rhus coriaria, *ſumach*†.
Rheum rhaponticum||.
Agave Americana¶.
The roots of triticum repens†.
Leontodon taraxicum†.

* Vauquelin, Ann. de Chim. v. 92.
† Hermſtadt on Veget. Acids.
|| Bindheim, Crell, 1788, St. 7. s. 42.
¶ Hoffman of Weimar.
† Hermſtadt on Veget. Acids.

71
Citric acid,

3. Citric acid is diſtinguiſhed by the following properties: It does not form tartar when potaſs is added to it. With lime it forms a ſalt inſoluble in water, which is decompoſed by ſulphuric, nitric, and muriatic acids. It readily cryſtallizes. It is deſtroyed by heat.

Citric acid has been found unmixed with other acids in the following vegetable ſubſtances*:

The juice of oranges and lemons.
The berries of vaccinium oxycoccos, *cranberry*.
—— —vitis idæa, *red whortle berry*.
Prunus padus, *birdcherry*.
Solanum dulcamara, *nightſhade*.
Roſa canina, *hip*.

* Scheele, Crell's Jour. ii. 8. Eng. Tranſl.

It occurs mixed with other acids in many other fruits.

72
Malic acid,

4. Malic acid is known by the following properties: It forms with lime a ſalt ſoluble in water, which is decompoſed by citric acid. It does not form tartar with potaſs. It is incryſtallizable. Heat deſtroys it.

Malic acid has been found, by Scheele†, in the fruits of the following plants, which contain no other acid:

Apples.
Berberis vulgaris, *barberry*.
Prunus domeſtica, *plum*.
—— ſpinoſa, *ſloe*.
Sambucus nigra, *elder*.
Sorbus aucuparia, *roan* or *ſervice*.

† Ibid.

73
Malic and citric.

In the following fruits he found nearly an equal quantity of malic and citric acids‡.

Ribes groſſularia, *gooſeberry*.
—— rubrum, *currants*.
Vaccinium myrtillus, *bleaberry*.
Crategus aria, *beam*.
Prunus ceraſus, *cherry*.
Fragaria veſca, *ſtrawberry*.
Rubus chamæmorus, *cloudberries*, *evrochs*.
—— idæus, *raſpberry*.

‡ Ibid.

Malic acid has alſo been found in the agave americana§, and in the pulp of tamarinds||. In the firſt of theſe it is mixed with tartarous acid; in the ſecond with tartarous and citric acids.

§ Hoffman of Weimar.
|| Vauquelin, Ann. de Chim. v. 92.

74
Gallic acid,

5. Gallic acid is known by the following properties: With the brown oxide of iron it produces a black colour. It is cryſtallizable. Heat deſtroys it. It has been found in a great number of plants, chiefly in the bark.—The following table, drawn up by Mr Biggin*, will ſerve to ſhew the relative proportions of this acid in different plants:

* Nicholſon's Journal, iii. 394.

Elm	7	Sallow	8
Oak cut in winter	8	Mountain aſh	8
Horſe cheſnut	6	Poplar	8
Beech	7	Hazel	9
Willow (boughs)	8	Aſh	10
Elder	4	Spaniſh cheſnut	10
Plum tree	8	Smooth oak	10
Willow (trunk)	9	Oak cut in ſpring	10
Sycamore	6	Huntingdon or Leiceſter willow	10
Birch	4		
Cherry tree	8	Sumach	14

75
Benzoic acid,

6. Benzoic acid is diſtinguiſhed by its aromatic odour, and its votality on the application of a very moderate heat. It has been found hitherto only in three vegetable ſubſtances, to which the French chemiſts have confined the term *balſam*. Theſe three are, *benzoin*, *balſam of tolu*, and *ſtorax*. In theſe ſubſtances it ſeems to be combined with a reſin, or ſomething which has nearly the properties of a reſin.

7. Phoſ-

Alkalies.

76 Phoſphoric acid.

7. Phoſphoric acid is eaſily diſtinguiſhed from the former ſix, for it is very fixed, and a violent heat does not deſtroy it as it does the others.

Phoſphoric acid has been found in different plants, but only in very ſmall quantities; it is almoſt conſtantly combined with lime. Meyer found it in the leaves of many trees*; Thuren found phoſphat of lime in the Aconitus Napellus†; and Bergmann found it in all kinds of grain‡.

* Enc. Meth. Phyſiol. Veg. i. 100. † Ann. de Chim. ii. 8. ‡ Bergmann, 96.

SECT. XVI. *Of Alkalies.*

THE only alkalies found in plants are potaſs and ſoda. Ammonia may indeed be obtained by diſtilling many vegetable ſubſtances, but it is produced during the operation. One or other of theſe alkalies is found in every plant which has hitherto been examined. The quantity indeed is uſually very ſmall.

77 Proportion of potaſs in plants.

1. Potaſs is found in almoſt all plants which grow at a diſtance from the ſea. It may be extracted by burning the vegetable, waſhing the aſhes in water, filtrating the water, and evaporating it to dryneſs. It is in this manner that all the potaſh of commerce is procured.

The following table exhibits the quantity of aſhes and potaſs which may be extracted from 100 parts of various plants:

	Aſhes.	*Potaſs.*
Sallow	2.8	0.285*(c)
Elm	2.36727	0.39*
Oak	1.35185	0.15343
Poplar	1.23476	0.07481
Hornbeam	1.1283	0.1254
Beech	0.58432	0.14572
Fir	0.34133	
Vine branches	3.379	0.55*
Common nettle	10.67186	2.5033
Common thiſtle	4.04265	0.53734
Fern	5.00781	0.6259
Cow thiſtle	10.5	1.96603
Great river ruſh	3.85395	0.72234
Feathered ruſh	4.33593	0.50811
Stalks of turkey wheat	8.86	1.75*
Wormwood	9.744	7.3*
Fumitory	21.9	7.9*
Trifolium pratenſe		0.078*
Vetches		2.75*
Beans with their ſtalks		2.0*

In general, three times as much aſhes are obtained from ſhrubs, and five times as much from herbs, as from trees. Equal weights of the branches of trees produce more aſhes than the trunk, and the leaves more than the branches. Herbs arrived at maturity produce more aſhes than at any other time. Green vegetables produce more aſhes than dry†.

† Ann. de Chim. xix. 4.

The ſalt which is obtained from plants does not conſiſt wholly of potaſs, there are other ſalts mixed with it; theſe uſually are ſulphat of potaſs, muriat of potaſs, ſulphat of lime, phoſphat of lime, &c.; but theſe bear, in general, but a ſmall proportion to the potaſs. The aſhes conſiſt of potaſs mixed with earths.

Some judgment may be formed of the quantity of potaſs which a plant contains from the quantity of aſhes which it yields: but the above table is ſufficient to ſhew us, that were we to truſt to that we would often be miſled.

Earths.

78 Soda.

2. Soda is found in almoſt all the plants which grow in the ſea, and in many of thoſe which grow on the ſhore. In general, the quantity of ſoda which plants contain bears a much greater proportion to their weight than the potaſs does which is found in inland vegetables. 100 parts of the *ſalſola ſoda*, for inſtance, yield 19.921 of aſhes; and theſe contain 1.992 parts of ſoda, ſome of which, however, is combined with muriatic acid*. The plants from which the greater part of the ſoda, or *barilha*, as it is called, which is imported from Spain, is extracted, are the *ſalſola ſativa*, and *vermiculata*.

* Vauquelin, Ann. de Chim. xviii. 77.

SECT. XVII. *Of Earths.*

THE only earths hitherto found in plants are the four following; *lime, ſilica, magneſia, alumina.*

79 Lime.

1. Lime is uſually the moſt abundant of the earths of plants, and the moſt generally diffuſed over the vegetable kingdom. Indeed, it is a very uncommon thing to find a plant entirely deſtitute of lime: ſalſola ſoda is almoſt the only one in which we know for certain that this earth does not exiſt*.

* Id. ibid.

80 Silica.

2. Silica exiſts alſo in many plants, particularly graſſes and equiſetums. Mr Davy has aſcertained, that it forms a part of the epidermis, or outermoſt bark of theſe plants; and that in ſome of them almoſt the whole epidermis is ſilica.

		Parts Silica.
100 parts of the epid. of	bonnet-cane yielded	90
	bamboo	71.4
(arundo phragm.)	common reed	48.1
	ſtalks of corn	6.5

The concretions which are ſometimes found in the bamboo cane have been aſcertained by Mr Macie to be compoſed of pure ſilica.

81 Magneſia.

3. Magneſia does not exiſt ſo generally in the vegetable kingdom as the two preceding earths. It has been found, however, in conſiderable quantities in ſeveral ſea plants, eſpecially fuci†. But the ſalſola ſoda contains a greater proportion of magneſia than any plant hitherto examined. Mr Vauquelin found that 100 parts of it contained 17.929 of that earth‡.

† Id. ibid. 80. and ix. 94. ‡ Ibid. 78.

82 Alumina.

4. Alumina has only been found in very ſmall quantities in plants.

83 Proportion of earths in plants.

The following table will ſhew the quantity of theſe four earths which exiſt in ſeveral vegetables.

100 parts of oak contain of earths	1.03*
Beech	0.453†
Fir	0.003†
Turkey wheat	7.11†
Sunflower	3.72†
Vine branches	2.85†
Box	2.674†
Willow	2.515†
Elm	1.96†
Aſpin	1.146†
Fern	3.221‡
Wormwood	2.444§
Fumitory	14.000§

* Watſon. † Kirwan, Iriſh Tranſ. iii. 35. ‡ Home. § Weigleb.

(c) Thoſe marked * are from *Kirwan, Iriſh Tranſ.* v. 164. The reſt from *Pertuis, Ann. de Chim.* 19. 178.

Metals.

This table ſhews us, that the quantity of earth is greater in herbs than in trees.

Bergman found all the four earths in every kind of grain which he analyſed *.

* Opuſc. v. 94.

Vauquelin found, that 100 parts of oat grain left 3 1591 of reſiduum. This reſiduum is compoſed of

60.7 ſilica,
39.3 phoſphat.

———

100.0 †.

† Ann. de Chim. xxix. 17.

When the whole of the avena ſativa, however, ſtalk and ſeed together, are burnt, they leave a reſiduum compoſed of

55 ſilica,
15 phoſphat of lime,
20 potaſs,
5 carbonat of lime.

———

95, and a little oxide of iron ‡.

‡ Ibid. 19.

This ſhews us that the ſtalk contains ſeveral ſubſtances not to be found in the grain.

SECT. XVIII. *Of Metals.*

SEVERAL metallic ſubſtances have alſo been found in vegetables, but their quantity is exceedingly ſmall; ſo ſmall, indeed, that without very delicate experiments their preſence cannot even be detected.

84 Three metals found in plants.

The metals hitherto diſcovered are iron, which is by far the moſt common, mangane$ſ$e, and gold.

Scheele firſt detected mangane$ſ$e in vegetables *. Prouſt found it in the aſhes of the pine, calendula, vine, green oak, and fig-tree †. M. Sage has ſhewn, that gold exiſts in many plants. Iron exiſts in moſt plants. The aſhes of ſome ſpecies of ſalſola contain a conſiderable quantity of it.

* Opuſc. i. 106.
† Phil. Mag. v. 99.

WE have now taken a ſurvey of all the ſubſtances which have hitherto been obtained from vegetables; by analyſing each of theſe, we come at laſt to thoſe bodies which we are at preſent obliged to conſider as ſimple, becauſe they have not yet been decompoſed, and of which accordingly we muſt ſuppoſe that vegetables are ultimately compoſed. Theſe bodies amount to 16, namely,

85 Simple ſubſtances contained in plants.

1. Oxygen,	9. Gold,
2. Sulphur,	10. Lime,
3. Phoſphorus	11. Magneſia,
4. Carbon,	12. Silica,
5. Hydrogen,	13. Alumina,
6. Azot,	14. Potaſs,
7. Iron,	15. Soda,
8. Mangane$ſ$e,	16. Muriatic acid.

But of theſe ſubſtances there are twelve which compoſe but a very ſmall proportion indeed of vegetables. Almoſt the whole of vegetable ſubſtances are compoſed of four ingredients, namely,

Carbon, Oxygen,
Hydrogen, Azot.

Of theſe the laſt, namely azot, forms but a ſmall proportion even of thoſe vegetable ſubſtances of which it is a conſtituent part, while into many it does not enter at all: So that, upon the whole, by far the greater part of vegetable ſubſtances is compoſed of carbon, hydrogen, and oxygen. We do not mention caloric and light, concerning the nature of which too little is known to enable us to determine with certainty into what ſubſtances they enter.

Vegetation.

The ſubſtances at preſent known to chemiſts, which they have not been hitherto able to decompoſe, amount (omitting caloric and light) to 40. Sixteen of theſe exiſt in plants; the other 24 belong excluſively to the mineral kingdom: for it is a fact, that no ſubſtance (we mean ſimple ſubſtance) has been hitherto found in the animal kingdom which does not exiſt alſo in vegetables.

On the contrary, all the ſimple ſubſtances at preſent known may be found in minerals. This indeed ought not to ſurpriſe us, if we recollect, that the ſpoils of animals and vegetables, after they have undergone decompoſition, are ultimately confounded with minerals, and conſequently arranged under the mineral kingdom. Beſides, as vegetables draw all their food from the mineral kingdom, it would be abſurd to ſuppoſe that they contain ſubſtances which they could not have procured from minerals. It muſt follow, therefore, of neceſſity, that minerals contain all the ſimple ſubſtances which exiſt in this globe of our's; and that plants owe their diverſity merely to different modifications of thoſe principles which they imbibe from the ſoil. But it is impoſſible to have any preciſe notions about a ſubject ſo intricate, without conſidering with ſome attention the ſtructure of vegetables, the food which they imbibe, and the changes which they produce on that food. Theſe enquiries ſhall form the ſubject of the next chapter; in which we propoſe to take a view of thoſe phenomena of vegetation which are connected with chemiſtry, or which may be elucidated by the application of the principles of that ſcience.

CHAP. II. OF VEGETATION.

WE have now ſeen the different ſubſtances which are contained in plants; but we have ſtill to examine the manner in which theſe ſubſtances are produced, and to endeavour to trace the different proceſſes which conſtitute vegetation. We muſt warn our readers not to expect complete information in this chapter. The wonders of the vegetable kingdom are ſtill but very imperfectly explored; many of the organs of plants are too minute for our ſenſes; and ſcarcely a ſingle proceſs can be completely traced.

86 Phenomena of vegetation very numerous.

The multiplicity of operations continually going on in vegetables at the ſame time, and the variety of different, and even oppoſite ſubſtances, formed out of the ſame ingredients, and almoſt in the ſame place, aſtoniſh and confound us. The order, too, and the ſkill with which every thing is conducted, are no leſs ſurpriſing. No two operations claſh; there is no diſcord, no irregularity, no diſturbance; every object is gained, and every thing is ready for its intended purpoſe. This is too wonderful to eſcape our obſervation, and of too much importance not to claim our attention. Many philoſophers, accordingly, diſtinguiſhed equally by their induſtry and ſegacity, have dedicated a great part of their lives to the ſtudy of *vegetation*. But hitherto their ſucceſs has not been equal to their exertions. No perſon has been able to detect this *agent*, always ſo buſy, and performing ſuch wonders, or to diſcover him at his work; nor have philoſophers been much more fortunate

Vegetation.

nate in their attempts to aſcertain the inſtruments which he employs in his operations. A great variety, however, of curious and intereſting facts, have been diſcovered. Theſe we ſhall attempt in this chapter to collect and arrange, to point out their dependence on each other, and perhaps to deduce ſuch conſequences as obviouſly reſult from their mutual dependence.

87 Plants ariſe from ſeed.

1. Natural hiſtorians have proved, by a very complete induction of facts, that all plants ariſe from *ſeeds*. The pretended exceptions have diſappeared, one after another, as our knowledge of vegetables increaſed: and now there remains ſcarcely a ſingle objection entitled to the ſmalleſt regard. The late attempt of Girtanner * to revive the doctrine of equivocal generation, deſerves no attention whatever; becauſe his concluſions are abſolutely incompatible with the *experiments* of Mr Senebier upon the very ſubſtance on which his theory is founded.

* Ann. de Chim. xxxiv. 5.

88 Seeds compoſed of three parts.

A SEED conſiſts of three parts; namely, the *cotyledons*, the *radicle*, and the *plumula*, which are uſually incloſed in a cover.

If we take a garden bean, we may perceive each of theſe three parts with great eaſe; for this ſeed is of ſo large a ſize, that all its organs are exceedingly diſtinct.

When we ſtrip off the external coats of the bean, which are two, and of different degrees of thickneſs in different parts, we find that it eaſily divides into two lobes, pretty nearly of the ſame ſize and figure. Each of theſe lobes is called a *cotyledon* (fig. 1. *a*). The cotyledons of the bean, then, are two in number.

Plate XLIII.

Near that part of the lobes which is contiguous to what is called the *eye* of the bean, there is a ſmall round white body (*b*), which comes out between the two lobes. This body is called the *radicle*.

Attached to the radicle, there is another ſmall round body (*c*), which lies between the cotyledons and wholly within them, ſo that it cannot be ſeen till they are ſeparated from each other. This body is called the *plumula*.

The appearance and ſhape of theſe three parts differ very much in different ſeeds, but there is no ſeed which wants them. The figure and ſize of the ſeed depend chiefly upon the cotyledons. This is evidently the caſe with the bean, and it is ſo with all other ſeeds. The number of cotyledons is different in different ſeeds. Some ſeeds have only one cotyledon, as the ſeeds of wheat, oats, barley, and the whole tribe of graſſes: ſome have three; others ſix, as the ſeeds of the garden graſs; but moſt ſeeds, like the bean, have two cotyledons.

89 Germination of ſeeds.

2. When a ſeed is placed in a ſituation favourable to vegetation, it very ſoon changes its appearance. The radicle is converted into a root, and ſinks into the earth; the plumula, on the other hand, riſes above the earth, and becomes the trunk or ſtem. When theſe changes take place, the ſeed is ſaid to *germinate*: the proceſs itſelf has been called *germination*. Seeds do not germinate equally and indifferently in all places and ſeaſons. Germination, therefore, is a proceſs which does not depend upon the ſeed alone; ſomething external muſt alſo affect it.

90 Requires moiſture,

3. It is a well known fact, that ſeeds will not germinate unleſs *moiſture* have acceſs to them; for ſeeds, if they are kept perfectly dry, never vegetate at all, and yet their power of vegetating is not deſtroyed. There are indeed ſome apparent objections to this; potatoes, for inſtance, and other bulbous bodies, germinate, tho' kept ever ſo dry. But the reaſon of this is, that theſe bodies (which are not ſeeds, though they reſemble them in ſome particulars) have a ſufficient quantity of water within themſelves to give a beginning to germination. We may conclude, then, that no ſeed will germinate unleſs water has acceſs to it. *Water*, then, is eſſential to germination. Too much water, however, is no leſs prejudicial to moſt ſeeds than none at all. The ſeeds of water plants, indeed, germinate and vegetate extremely well in water; but moſt other ſeeds, if they are kept in water beyond a certain time, are rotted and deſtroyed altogether.

91 Heat,

4. It is well known alſo, that ſeeds will not germinate, even though ſupplied with water, provided the temperature be below a certain degree. No ſeed, for inſtance, on which the experiment has been tried, can be made to vegetate at or below the freezing point: yet this degree of cold does not injure the vegetating power of ſeeds; for many ſeeds will vegetate, as well as ever, after having been frozen, or after having been kept in frozen water. We may conclude, then, that a certain degree of heat is neceſſary for the germination of ſeeds. And every ſpecies of plants ſeems to have a degree peculiar to itſelf, at which its ſeeds begin to germinate; for we find that almoſt every ſeed has a peculiar ſeaſon at which it begins to germinate, and this ſeaſon varies always according to the temperature of the air. Mr Adanſon found that ſeeds, when ſown at the ſame time in France and in Senegal, always appeared ſooner above ground in the latter country, where the climate is hotter, than in France §.

§ Enc. Meth. Phyſiol. Veget. 124.

92 And oxygen gas.

5. Seeds, although ſupplied with moiſture, and placed in a proper temperature, will not germinate, provided atmoſpherical air be completely excluded from them. Mr Ray found that grains of lettuce did not germinate in the vacuum of an air-pump, but they began to grow as ſoon as air was admitted to them †. Homberg made a number of experiments on the ſame ſubject, which were publiſhed in the Memoirs of the French Academy for the year 1693. He found, that the greater number of ſeeds which he tried refuſed to vegetate in the vacuum of an air-pump. Some, however, did germinate; but Boyle, Muſchenbroek, and Boerhaave, who made experiments on the ſame ſubject in ſucceſſion, proved beyond a doubt that no plant vegetates in the vacuum of an air-pump; and that in thoſe caſes in which Homberg's ſeeds germinated, the vacuum was far from perfect, a quantity of air ſtill remaining in the receiver. It follows, therefore, that no ſeed will germinate unleſs atmoſpherical air, or ſome air having the ſame properties, have acceſs to it. It is for this reaſon that ſeeds will not germinate at a certain depth below the ſurface of the earth.

† Phil. Tranſ. No 53.

Mr Scheele found that beans would not germinate except oxygen gas were preſent; Mr Achard afterwards proved, that oxygen gas is abſolutely neceſſary for the germination of all ſeeds, and that no ſeed will germinate in azotic gas, or hydrogen gas, or carbonic acid gas, unleſs theſe gaſes contain a mixture of oxygen gas. Theſe experiments have been confirmed by Mr

Vegetation.

Mr Gough, Mr Cruickſhank, and many other philoſophers. It follows, therefore, that it is not the whole atmoſpheric air, but merely the oxygen gas which it contains, that is neceſſary for the germination of ſeeds.

93 Injured by the preſence of light.

6. Seeds do not germinate equally well when they are expoſed to the light, and when they are kept in a dark place; light therefore has ſome effect on germination.

Mr Ingenhouſz found, that ſeeds always germinate faſter in the dark than when expoſed to the light *. His experiments were repeated by Mr Senebier with equal ſucceſs †; and it was concluded, in conſequence of their experiments, that light is injurious to germination. But the Abbé Bertholin, who diſtinguiſhed himſelf ſo much by his labours to demonſtrate the effect of electricity on vegetation, objected to the concluſions of theſe philoſophers, and affirmed that the difference in the germination of ſeeds in the ſhade and in the light was owing, not to the light itſelf, but to the difference of the moiſture in the two ſituations; the moiſture evaporating much faſter from the ſeeds in the light than from thoſe in the ſhade; and he affirmed, that when precautions were taken to keep the ſeeds equally moiſt, thoſe in the ſun germinated ſooner than thoſe in the ſhade ‡. But when Mr Senebier repeated his former experiments, and employed every poſſible precaution to enſure the equality of moiſture in both ſituations, he conſtantly found the ſeeds in the ſhade germinate ſooner than thoſe in the light §. We may conclude, therefore, that light is injurious to germination; and hence one reaſon for covering ſeeds with the ſoil in which they are to grow.

* *Experience ſur les Vegetaux*, ii

† *Mem. Phyſico-chimique*, iii. 341.

‡ *Jour. de Phyſ.* 1789, Decemb.

§ *Enc. Meth. Phyſiol. Veget.* 126.

7. Thus we have ſeen that ſeeds will not germinate unleſs *moiſture*, *heat*, and *oxygen gas*, be preſent; and that they do not germinate well if they are expoſed to the action of *light*. Now, in what manner do theſe ſubſtances affect the ſeed? What are the changes which they produce?

94 Phenomena of germination.

We obſerved before, that all ſeeds have one or more cotyledons. Theſe cotyledons contain a quantity of farinaceous matter, laid up on purpoſe to ſupply the embryo plant with food as ſoon as it begins to require it. This food, however, muſt undergo ſome previous preparation, before it can be applied by the plant to the formation or completion of its organs. Now all the phenomena of germination, which we can perceive, conſiſt in the chemical changes which are produced in that food, and the conſequent developement of the organs of the plant.

95 The cotyledons prepare food,

When a ſeed is placed in favourable circumſtances, it gradually imbibes moiſture, and very ſoon after emits a quantity of carbonic acid gas, even though no oxygen gas be preſent *. This ſeems to prove, as Mr Cruickſhank has ſuppoſed, that ſome of the water imbibed by the ſeed is decompoſed, that its oxygen combines with part of the carbon of the farina, and goes off in the form of carbonic acid gas, while the hydrogen remains behind, and combines with the ingredients contained in the cotyledon. The firſt part of germination, then, conſiſts in diminiſhing the quantity of carbon, and increaſing the hydrogen of the farina. If no oxygen gas be preſent, the proceſs ſtops here, and no germination takes place.

* *Gough, Manch. Mem.* iv. 315. *Cruickſhank, Rollo on Diabetes*, p. 452.

But if oxygen gas be preſent, it is gradually abſorbed and retained by the ſeed; and at the ſame time, the farina of the cotyledons aſſumes a ſweet taſte reſembling ſugar: it is therefore converted into ſugar, or ſome ſubſtance analogous to it *. Farina, then, is changed into ſugar, by diminiſhing its carbon, and augmenting the proportion of its hydrogen and oxygen. This is preciſely the proceſs of malting, or of converting grain into malt; during which it is well known that there is a conſiderable heat evolved; ſo much indeed, that in certain circumſtances grain improperly kept has even taken fire. We may conclude from this, that during the germination of ſeeds in the earth there is alſo an evolution of a conſiderable portion of heat. This indeed might have been expected, as it uſually happens when oxygen gas is abſorbed.

* *Ibid.*

So far ſeems to be the work of chemiſtry alone; at leaſt we have no right to conclude that any other agent interferes; ſince *hay*, when it happens to imbibe moiſture, exhibits nearly the ſame proceſſes. Carbonic acid gas is evolved, oxygen gas is abſorbed, heat is produced ſo abundantly, that the hay often takes fire: at the ſame time a quantity of ſugar is formed. It is owing to a partial change of the ſame kind that old hay generally taſtes much ſweeter than new hay. Now we have no reaſon to ſuppoſe that any agents peculiar to the vegetable kingdom reſide in hay; as all vegetation, and all power of vegetating, are evidently deſtroyed.

96 Which paſſes into the radicle,

But when the farina in the ſeeds of vegetables is converted into ſugar, a number of veſſels make their appearance in the cotyledon. The reader will have a pretty diſtinct notion of their diſtribution, by inſpecting fig. 2. Theſe veſſels may indeed be detected in many ſeeds before germination commences, but they become much more diſtinct after it has made ſome progreſs. Branches from them have been demonſtrated by Grew, Malpighi, and Hedwig, paſſing into the radicle, and diſtributed through every part of it. Theſe evidently carry the nouriſhment prepared in the cotyledons to the radicle; for if the cotyledons be cut off even after the proceſſes above deſcribed are completed, germination, as Bonnet and Senebier aſcertained by experiment, immediately ſtops. The food therefore is conveyed from the cotyledons into the radicle, the radicle increaſes in ſize, aſſumes the form of a *root*, ſinks down into the earth, and ſoon becomes capable of extracting the nouriſhment neceſſary for the future growth of the plant. Even at this period, after the radicle has become a perfect root, the plant, as Senebier aſcertained by experiment, ceaſes to vegetate if the *cotyledons* be cut off. They are ſtill then abſolutely neceſſary for the vegetation of the plant.

97 And converts it into a root.

98 Cotyledons become ſeminal leaves.

The cotyledons now aſſume the appearance of leaves, and appear above the ground, forming what are called the *ſeminal leaves* of the plant. After this the *plumula* gradually increaſes in ſize, riſes out of the earth, and expands itſelf into branches and leaves. The ſeminal leaves, ſoon after this, decay and drop off, and the plant carries on all the proceſſes of vegetation without their aſſiſtance.

Mr Eller attempted to ſhew, that there is a veſſel in ſeeds which paſſes from the cotyledons to the plumula; but later anatomiſts have not been able to perceive any ſuch veſſel. Even Mr Hedwig, one of the moſt patient, acute, and ſucceſsful philoſophers that ever turned their attention to the ſtructure of vegetables, could never

Vegetation.

never discover any such vessel, although he traced the vessels of the cotyledons even through the radicle. As it does not appear, then, that there is any communication between the cotyledons and the plumula, it must follow that the nourishment passes into the plumula from the radicle: and accordingly we see, that the plumula does not begin to vegetate till the radicle has made some progress. Since the plant ceases to vegetate, even after the radicle has been converted into a root, if the cotyledons be removed before the plumula is developed, it follows, that the radicle is insufficient of itself to carry on the processes of vegetation, and that the cotyledons still continue to perform a part. Now we have seen already what that part is: they prepare *food* for the nourishment of the plant. The root, then, is of itself insufficient for this purpose. When the cotyledons assume the form of seminal leaves, it is evident that the nourishment which was originally laid up in them for the support of the embryo plant is exhausted, yet they still continue as necessary as ever. They must therefore receive the nourishment which is imbibed by the root; they must produce some changes on it, render it suitable for the purposes of vegetation, and then send it back again to be transmitted to the plumula.

99 Which prepare the food sent from the root.

After the plumula has acquired a certain size, which must be at least a *line*, if the cotyledons be cut off, the plant, as Mr Bonnet ascertained by a number of experiments, afterwards repeated with equal success by Mr Senebier, does not cease to vegetate, but it continues always a mere pigmy: its size, when compared with that of a plant whose cotyledons are allowed to remain, being only as 2 to 7 *.

* *Enc. Meth. Physiol. Veget.* 41

When the plumula has expanded completely into leaves, the cotyledons may be removed without injuring the plant, and they very soon decay of themselves. It appears, then, that this new office of the cotyledons is afterwards performed by that part of the plant which is above ground.

100 Plumula forms the stem and leaves.

Thus we have traced the phenomena of germination as far as they have been detected. The facts are obvious; but the *manner* in which they are produced is a profound secret. We can neither explain how the food enters into the vessels, how it is conveyed to the different parts of the plant, how it is deposited in every organ, nor how it is employed to increase the size of the old parts, or to form new parts. These phenomena are analogous to nothing in mechanics or chemistry. He that attempts to explain them on the principles of these sciences, merely substitutes new meanings of words instead of old ones, and gives us no assistance whatever in conceiving the processes themselves. As the substances employed in vegetation are all material, it is evident that they possess the properties of matter, and that they are arranged in the plant according to these laws. It follows, therefore, that all the changes which take place in the plant are produced according to the known laws of mechanics and chemistry. This cannot be disputed: but it explains nothing; for what we want to know is the *agent* that brings every particle of matter to its proper place, and enables the laws of chemistry and mechanics to act only in order to accomplish a certain end. Who is the agent that acts according to this end? To say that it is chemistry or mechanics, is to pervert the use of words. For what are the laws of chemistry and mechanics? Are they not certain fixed and unalterable properties of matter? Now, to say that a property of matter has an end in view, or that it acts in order to accomplish some design, is a downright absurdity. There must therefore be some agent in all cases of germination, which regulates and directs the mechanical and chemical processes, and which therefore is neither a mechanical nor chemical property.

8. When the process of germination is accomplished, the plant is complete in all its parts, and capable of vegetating in a proper soil, for a time and with a vigour proportional to its nature. 101

Plants composed of bark, wood, and pith.

Plants, as every body knows, are very various, and of course the structure of each species must have many peculiarities. Trees have principally engaged the attention of anatomists, on account of their size and the distinctness which they expected to find in their parts. We shall therefore take a tree as an instance of the structure of plants; and we shall do it the more readily, as the greater number of vegetables are provided with analogous organs, dedicated to similar uses.

A TREE is composed of a *root*, a *trunk*, and *branches*; the structure of each of which is so similar, that a general description of their component parts will be sufficient. Each of them consists of three parts, the *bark*, the *wood*, and the *pith*. 102

Bark.

The BARK is the outermost part of the tree. It covers the whole plant from the extremity of the roots to the extremity of the branches. It is usually of a green colour: if a branch of a tree be cut across, the bark is easily distinguished from the rest of the branch by this colour. If we inspect such a horizontal section with attention, we shall perceive that the bark itself is composed of three distinct bodies, which, with a little care, may be separated from each other. The outermost of these bodies is called the *epidermis*, the middlemost is called the *parenchyma*, and the innermost, or that next the wood, is called the *cortical layers*. 103

Composed of epidermis,

The *epidermis* is a thin transparent membrane, which covers all the outside of the bark. It is pretty tough. When inspected with a microscope, it appears to be composed of a number of slender fibres crossing each other, and forming a kind of network. It seems even to consist of different thin retiform membranes, adhering closely together. This, at least, is the case with the epidermis of the birch, which Mr Duhamel separated into six layers. The epidermis, when rubbed off, is reproduced. In old trees it cracks and decays, and new epidermes are successively formed. This is the reason that the trunks of many old trees have a rough surface. 104

Parenchyma,

The *parenchyma* lies immediately below the epidermis; it is of a deep green colour, very tender, and succulent. When viewed with a microscope, it seems to be composed of fibres which cross each other in every direction, like the fibres which compose a hat. Both in it and the epidermis there are numberless interstices, which have been compared to so many small bladders. 105

And cortical layers.

The *cortical layers* form the innermost part of the bark, or that which is next to the wood. They consist of several thin membranes, lying the one above the other; and their number appears to increase with the age of the plant. Each of these layers is composed of longitudinal fibres, which separate and approach each other alternately, so as to form a kind of network. The meshes of this network correspond in each of the layers;

Vegetation.

ers; and they become smaller and smaller in every layer as it approaches the wood. These meshes are filled with a green coloured cellular substance, which has been compared by anatomists to a number of bladders adhering together, and communicating with each other.

106 Wood composed of

The WOOD lies immediately under the bark, and forms by far the greatest part of the trunk and large branches of trees. It consists of concentric layers, the number of which increases with the age of the part. Each of these layers, as Mr Du Hamel ascertained, may be separated into several thinner layers, and these are composed chiefly of longitudinal fibres. Hence the reason that wood may be much more easily split asunder than cut across.

The *wood*, when we inspect it with attention, is not, through its whole extent, the same; the part of it next the bark is much softer and whiter, and more juicy than the rest, and has for that reason obtained a particular name: it has been called the *alburnum* or *aubier*.

107 Alburnum and perfect wood,

The *perfect wood* is browner, and harder, and denser, than the alburnum, and the layers increase in density the nearer they are to the centre. Sir John Hill gave to the innermost layer of wood the name of *corona*, or rather he gave this name to a thin zone which, according to him, lies between the wood and the pith.

108 Pith,

The PITH occupies the centre of the wood. It is a very spongy body, containing a prodigious number of cells, which anatomists have compared to bladders. In young shoots it is very succulent; but it becomes dry as the plant advances, and at last in the large trunks of many trees disappears altogether.

109 Leaves.

The LEAVES are attached to the branches of plants by short footstalks. From these footstalks a number of fibres issue, which ramify and communicate with each other in every part of the leaf, and form a very curious network. These fibres may be obtained separately, by keeping the leaf long in moisture. Every other part of it putrefies and falls off, or may easily be rubbed off, and only the fibres remain, constituting a skeleton of the leaf. In every leaf there are two layers of these fibres, forming two distinct skeletons, which had constituted the upper and under surface of the leaf.

The whole leaf is covered with the epidermis of the plant; and this epidermis, as Saussure has shewn, contains in it a great number of glands. The other parts of the bark may also be traced on many leaves; at least Saussure has shewn, that the *bark* of leaves is composed of two different layers. The interstices between the fibres of the leaf are filled up by a pulpy-like substance, to which the green colour of the leaf is owing.

Such is a short description of the most conspicuous parts of plants. A more minute account would have been foreign to the subject of the present article.

110 Plants increase in size.

9. Plants, after they have germinated, do not remain stationary, but are continually increasing in size. A tree, for instance, every season, adds considerably to its former bulk. The root sends forth new shoots, and the old ones become larger and thicker. The same increment takes place in the branches and the trunk. When we examine this increase more minutely, we find that a new layer of wood, or rather of alburnum, has been added to the tree in every part, and this addition has been made just under the bark. We find, too, that a layer of alburnum has assumed the appearance of perfect wood. Besides this addition of vegetable fibre, a great number of leaves have been produced; and the tree puts forth flowers, and forms seeds.

111 Therefore require food.

It is evident from all this, that a great deal of new matter is continually making its appearance in plants. Hence, since it would be absurd to suppose that they *create* new matter, it must follow that they receive it by some channel or other. Plants, then, require food as well as animals. Now, what is this food, and whence do they derive it? These questions can only be answered by an attentive survey of the substances which are contained in vegetables, and an examination of those substances which are necessary for their vegetation. If we could succeed completely, it would throw a great deal of light upon the nature of soils and of manures, and on some of the most important questions on agriculture. But we are far indeed at present from being able to examine the subject to the bottom.

112 Water necessary.

10. In the first place, it is certain that plants will not vegetate without water; for whenever they are deprived of it, they wither and die. Hence the well-known use of rains and dews, and the artificial watering of ground. We may conclude, then, that water is at least an essential part of the food of plants.

But many plants grow in pure water; and therefore it may be questioned whether water is not the only food of plants. This opinion was adopted very long ago, and numerous experiments have been made in order to demonstrate it. Indeed, it was the general opinion of the 17th century; and some of the most successful improvers of the physiology of plants, in the 18th century, have embraced it. The most zealous advocates for it were, Van Helmont, Boyle, Bonnet, Duhamel, and Tillet.

113 Supposed the whole food of plants;

Van Helmont planted a willow which weighed five pounds, in an earthen vessel filled with soil previously dried in an oven, and moistened with rain water. This vessel he sunk into the earth, and he watered his willow sometimes with rain, and sometimes with distilled water. After five years it weighed $169\frac{1}{4}$ lbs. and the earth in which it was planted, when again dried, was found to have lost only two ounces of its original weight. Here, it has been said, was an increase of 164 lb. and yet the only food of the willow was pure water; therefore it follows that pure water is sufficient to afford nourishment to plants. The insufficiency of this experiment to decide the question was first pointed out by Bergman in 1773 *. He shewed, from the experiments of Margraff, that the rain water employed by Van Helmont contained in it as much earth as could exist in the willow at the end of five years. For, according to the experiments of Margraff, 1 lb. of rain water contains 1 gr. of earth †. The growth of the willow, therefore, by no means proves that the earth which plants contain has been formed out of water. Besides, as Mr Kirwan has remarked ‡, the earthen vessel must have often absorbed moisture, from the surrounding earth, impregnated with whatever substance that earth contained; for unglazed earthen vessels, as Hales * and Tillet † have shewn, readily transmit moisture.

* *Opusc.* v. 92.

† *Opusc.* ii. 15. and 19.

‡ *Irish Transf.* v. 150.

* *Veget. Stat.* i. 5.

† *Mem. Par.* 1772. 298.

114 But without reason

Hence it is evident that no conclusion whatever can be drawn from this experiment; for all the substances which the willow contained, except water, may have been derived from the rain water, the earth in the pot, and the moisture imbibed from the surrounding soil.

The

Vegetation.

The experiments of Duhamel and Tillet are equally inconclusive; so that it is impossible from them to decide the question, Whether water be the sole nourishment of plants or not? We owe the solution of this difficulty to the experiments of Mr Hassenfratz, who pointed out the fallacy of those just mentioned.

He analysed the bulbous roots of hyacinths, in order to discover the quantity of water, carbon, and hydrogen, which they contained; and by repeating the analysis on a number of bulbs, he discovered how much of these ingredients was contained in a given weight of the bulb. He analysed also kidney beans and cress seeds in the same manner. Then he made a number of each of these vegetate in pure water, taking the precaution to weigh them beforehand, in order to ascertain the precise quantity of carbon which they contained. The plants being then placed, some within doors, and others in the open air, grew and flowered, but produced no seed. He afterwards dried them, collecting with care all their leaves and every other part which had dropt off during the course of the vegetation. On submitting each plant to a chemical analysis, he found that the quantity of carbon, which it contained, was somewhat less than the quantity which existed in the bulb or the seed from which the plant had sprung *.

* *Ann. de Chim.* xiii. 188.

Hence it follows irresistibly, that plants growing in pure water do not receive any increase of *carbon;* that the water merely serves as a vehicle for the carbonaceous matter already present, and diffuses it thro' the plant. Water, then, is not the sole food of plants; for all plants during vegetation receive an increase of carbonaceous matter, without which they cannot produce perfect seeds, nor even continue to vegetate beyond a certain time; and that time seems to be limited by the quantity of carbonaceous matter contained in the bulb or the seed from which they grow. For Duhamel found, that an oak which he had raised by water from an acorn, made less and less progress every year. We see, too, that those bulbous roots, such as hyacinths, tulips, &c. which are made to grow in water, unless they be planted in the earth every other year, refuse at last to flower, and even to vegetate; especially if they produce new bulbous roots annually, and the old ones decay.

115
A certain portion only proper.

So far, indeed, is water from being the sole food of plants, that in general only a certain proportion of it is serviceable, too much being equally prejudicial to them as too little. Some plants, it is true, grow constantly in water, and will not vegetate in any other situation; but the rest are entirely destroyed when kept immersed in that fluid beyond a certain time. Most plants require a certain degree of moisture, in order to vegetate well. This is one reason why different soils are required for different plants. Rice, for instance, requires a very wet soil: were we to sow it in the ground on which wheat grows luxuriously, it would not succeed; and wheat, on the contrary, would rot in the rice ground.

We should, therefore, in choosing a soil proper for the plants which we mean to raise, consider the quantity of moisture which is best adapted for them, and choose our soil accordingly. Now, the dryness or moisture of a soil depends upon two things; the nature and proportions of the earths which compose it, and the quantity of rain which falls upon it. Every soil contains at least three earths, silica, lime, and alumina, and sometimes also magnesia. The silica is always in the state of sand. Now soils retain moisture longer or shorter according to the proportions of these earths. Those which contain the greatest quantity of sand retain it the shortest, and those which contain the greatest quantity of alumina retain it longest. The first is a dry, the second a wet soil. Lime and magnesia are intermediate between these two extremes: they render a sandy soil more retentive of moisture, and diminish the wetness of a clayey soil. It is evident, therefore, that, by mixing together proper proportions of these four earths, we may form a soil of any degree of dryness and moisture that we please.

But whatever be the nature of the soil, its moisture must depend in general upon the quantity of rain which falls. If no rain at all fell, a soil, however retentive of moisture it be, must remain dry; and if rain were very frequently falling, the soil must be open indeed, if it be not constantly wet. The proportion of the different earths in a soil, therefore, must depend upon the quantity of rain which falls. In a rainy country, the soil ought to be open; in a dry country, it ought to be retentive of moisture. In the first, there ought to be a greater proportion of sand; in the second, of clay. 116

11. Almost all plants grow in the earth, and every soil contains at least silica, lime, alumina, and often magnesia. We have seen already, that one use of these earths is to administer the proper quantity of water to the vegetables which grow in the soil. But as all plants contain earths as a part of their ingredients, is it not probable that earths also serve as a food for plants? It has not yet indeed been shewn, that those plants which vegetate in pure water do not contain the usual quantity of earth; but as earths are absolutely necessary for the perfect vegetation of plants, as they are contained in all plants, and are even found in their juices, we can scarcely doubt that they are actually imbibed, though only in small quantities (D). 117

Earth necessary;

12. We have seen in the last chapter, that all plants contain various saline substances; and if we analyse the most fertile soils, and the richest manures, we never find them destitute of these substances. Hence it is probable that different salts enter as ingredients into the food of plants. It is probable also, that every plant absorbs particular kinds of salts. Thus sea plants yield soda by analysis, while inland plants furnish potass. The potass contained in plants has indeed been supposed to be the produce of vegetation; but this has not been proved in a satisfactory manner. We find potass in the very juices of plants, even more abundantly than in the vegetable fibres themselves. But this subject is still buried in obscurity; and indeed it is extremely difficult

And salts;

(D) Mr Tennant has ascertained, that magnesia, when uncombined with carbonic acid gas, is injurious to corn when employed as a manure; and that lime, which contains a mixture of magnesia, likewise injures corn.—See *Phil. Transf.* 1799, p. 2. This important fact demonstrates, that earths are not mere vehicles for conveying water to plants.

Vegetation.

ficult to make deciſive experiments, on account of the very ſmall quantity of potaſs which moſt plants contain.

The phoſphorus, too, and the iron, and other metals which are found in plants, are no doubt abſorbed by them as a part of their food. We may ſuppoſe alſo, that the ſulphuric and muriatic acids, and perhaps even the nitric acid, when found in plants, are imbibed by them along with the reſt of their aliment.

Nothing is at preſent known concerning thoſe ſaline ſubſtances which form an eſſential part of the food of plants; though it has been long remarked that certain ſalts are uſeful as manures.

118 And carbon,

13. Water, then, and earths, and perhaps alſo ſalts, form a part of the food of plants. But plants contain carbon, which cannot be derived from any of theſe ſubſtances; conſequently ſome ſubſtance or other beſides, which contains carbon, muſt conſtitute a part of the food of plants.

Mr Giobert mixed together the four earths, ſilica, alumina, lime, magneſia, in the proper proportions, to conſtitute a fertile ſoil; and after moiſtening them with water, planted ſeveral vegetables in them; but none of his plants grew well, till he moiſtened his artificial ſoil with water from a dunghill *. Now it is certain, from the experiments of Haſſenfratz, that this water contains carbon; for when evaporated, it conſtantly left behind it a reſiduum of charcoal †. We know likewiſe, from a great variety of experiments, that all fertile ſoils contain a conſiderable quantity of carbonaceous matter; for all of them, when expoſed to heat, are ſuſceptible of partial combuſtion, during which a quantity of carbonic acid gas eſcapes. Thus Fourcroy and Haſſenfratz found, that 9216 parts of fertile ſoil contained 305 parts of carbon, beſides 279 parts of oil; which, from the analyſis of Lavoiſier, we may ſuppoſe to contain about 220 parts of carbon. It follows, therefore, from the experiments of theſe chemiſts ‡, that 9216 parts of ſoil contain 525 parts of carbon. But theſe 9216 parts of ſoil contained 806 parts of roots of vegetables which were excluded from the analyſis; conſequently a fertile ſoil contains (excluſive of the roots of vegetables (about one-ſixteenth of its weight of carbon.

* *Encyc. Meth. Phyſ. Veget.* p. 275.

† *Ann. de Chim.* xiv. 56.

‡ *Encyc. Meth. Phyſ. Veget.* p. 277.

119 Which muſt be in a particular ſtate;

But the carbon muſt exiſt in the ſoil in a particular ſtate of combination, otherwiſe it does not anſwer as food for plants: For inſtance, powdered pitcoal, mixed with earths, is not found to act, at leaſt immediately, as a manure; yet pitcoal contains a very great quantity of carbon. Farther, it appears, from the experiments of Mr Haſſenfratz, that ſubſtances employed as manures produce effects in times proportioned to their degree of putrefaction; thoſe ſubſtances which are moſt putrid producing the moſt ſpeedy effects, and of courſe ſooneſt loſing their efficacy. Having manured two pieces of the ſame kind of ſoil, the one with a mixture of dung and ſtraw highly putrefied, the other with the ſame mixture newly made, and the ſtraw almoſt freſh, he obſerved that, during the firſt year, the plants which grew on the land manured with the putrefied dung produced a much better crop than the other; but the ſecond year (no new dung being added), the ground which had been manured with the unputrefied dung produced the beſt crop; the ſame thing took place the third year; after which, both ſeemed to be equally exhauſted *. Here it is evident that the putrefied dung acted ſooneſt, and was ſooneſt exhauſted. It follows from this, that carbon only acts as a manure when in a particular ſtate of combination; and this ſtate, whatever it may be, is evidently produced by putrefaction. Another experiment of the ſame chemiſt renders this truth ſtill more evident. He allowed ſhavings of wood to remain for about ten months in a moiſt place till they began to putrefy, and then ſpread them over a piece of ground by way of manure. The firſt two years this piece of ground produced nothing more than others which had not been manured at all; the third year is was better, the fourth year ſtill better, the fifth year it reached its maximum of fertility; after which it declined conſtantly till the ninth, when it was quite exhauſted †. Here the effect of the manure evidently depended upon its progreſs in putrefaction.

* *Ann. de Chim.* xiv. 57.

† *Ibid.* p. 58.

120 And ſoluble in water.

Now what is the particular ſtate into which carbon muſt be reduced before it be fit for the food of plants? This ſubject has never been examined with attention; the different combinations of carbon having been in a great meaſure overlooked. And yet it is evident, that it is only by an accurate examination of theſe combinations, and a thorough analyſis of manures, in order to diſcover what particular combinations of carbon exiſt in them, and in what the moſt efficacious manures differ from the reſt, that we can expect to throw complete light upon the nature and uſe of manures, one of the moſt important ſubjects to which the farmer can direct his attention. We know, from the experiments of Mr Haſſenfratz, that all thoſe manures which act with efficacy and celerity contain carbon in ſuch a ſtate of combination, that it is ſoluble in water, and that the efficacy of the manure is proportional to the quantity of carbon ſo ſoluble. He found that all efficacious manures gave a brown colour to water, and that the water ſo coloured, when evaporated, left a reſiduum, which conſiſted in a great meaſure of carbon *. He obſerved, too, that the ſoil which gives the deepeſt colour to water, or which contains the greateſt quantity of carbon ſoluble in water, is, other things being the ſame, the moſt fertile.

* *Ibid.* p. 56.

This is not, however, to be underſtood without limitation; for it is well known that if we employ exceſſive quantities of manure, we injure vegetation inſtead of promoting it. This is the reaſon that plants will not, as Mr Duhamel found by experiment, vegetate in ſaturated ſolutions of dung †.

† *Mem. Par.* 1748.

121 This ſtate not carbonic acid gas;

One of the combinations of carbon which is ſoluble in water, and with which we are beſt acquainted, is carbonic acid gas. It has been ſuppoſed by many philoſophers, particularly by Mr Senebier, that this gas, diſſolved in water, ſupplies plants with a great part of their carbon. But Mr Haſſenfratz, on making the experiment, found that the plants which he raiſed in water, impregnated with carbonic acid gas, differed in no reſpect from thoſe which grew in pure water, and did not contain a particle of carbon which had not exiſted in the ſeeds from which they ſprung ‡. This experiment proves, that carbonic acid gas, diſſolved in water, does not ſerve as food for plants. It appears, however, from the experiments of Ruckert, that when plants growing in ſoil are watered daily with water impregnated with carbonic acid gas, they vegetate faſter than when this watering is omitted. He planted two beans in

‡ *Ann. de Chim.* xiii. 320.

122 Though that gas is uſeful.

Vegetation.

in pots of equal dimenſions, filled with garden mould. One of theſe was watered almoſt daily with diſtilled water, the other with water, every ounce of which was impregnated with half a cubic inch of carbonic acid gas. Both were placed in the open air, but in a ſituation where they were ſecure from rain. The bean treated with the water impregnated with carbonic acid gas appeared above ground nine days before the other, and produced 25 beans; whereas the other produced only 15. The ſame experiment was tried on other plants with equal ſucceſs †. This ſhews us that carbonic acid gas is ſomehow or other uſeful to plants when they vegetate in mould; but it gives us no information about its mode of acting. Some ſoils, we know, are capable of decompoſing it; for ſome ſoils contain the green oxide of iron: and Gadolin has proved, that ſuch ſoils have the property of decompoſing carbonic acid gas *. Indeed almoſt all ſoils contain iron, either in the ſtate of the brown or the green oxide; and Beaumé has ſhewn, that oils convert the brown oxide of iron into the green †. Now dung contains a quantity of oily ſubſtance; and this is the caſe alſo with rich ſoils. One uſe of manures, therefore, may be, to reduce the brown oxide of iron to the green, that it may be capable of decompoſing carbonic acid gas; and the carbon, thus precipitated, doubtleſs enters into ſome new combination, in which ſtate it ſerves as food for plants.

Mr Humbolt has lately proved, that ſoils have the property of abſorbing oxygen. It can ſcarcely be doubted that this abſorption has an influence on vegetation, eſpecially as watering plants with weak ſolutions of oxy-muriatic acid accelerates vegetation *. But we know too little of the ſubject at preſent to be able to ſpecify preciſely what that influence is.

123 Food abſorbed by the roots.

14. Since the only part of plants which is contiguous to the ſoil is the root, and ſince the plant periſhes when the root is pulled out of the ground, it is evident that the food of plants muſt be imbibed by the roots.

When we examine the roots, we do not find them to contain any large opening. The paſſages by which the food enters are too ſmall for the naked eye. This ſhews us that the food can enter plants only in a fluid ſtate; and that conſequently every thing which can be rendered uſeful as food for plants muſt be previouſly in a ſtate of ſolution.

It ſeems moſt probable, that the whole, or the greateſt part of the food, enters at the extremities of the roots; for Duhamel obſerved, that the portion of the ſoil which is ſooneſt exhauſted, is preciſely that part in which the greateſt number of the extremities of roots lies ‡. This ſhews us the reaſon why the roots of plants are continually increaſing in length. By this means they are enabled, in ſome meaſure, to go in queſt of nouriſhment. The extremities of the roots ſeem to have a peculiar ſtructure adapted for the imbibing of moiſture. If we cut off the extremity of a root, it never increaſes any more in length: therefore its uſe as a root has been in a great meaſure deſtroyed. But it ſends out fibres from its ſides which act the part of roots, and imbibe food by their extremity. Nay, in ſome caſes, when the extremity of a root is cut off, the whole decays, and a new one is formed in its place. This, as Dr Bell informs us, is the caſe with the hyacinth †.

† Crell's Annals, 1788. ii. 399.

* Ibid. 1791, i. 53.

† Kirwan, Iriſh Tranſ. v. 156.

* Ingenhouſz.

‡ Phyſique des Arbres, ii. 239.

† Manch. Mem. ii. 112.

Since the food of plants muſt be in a fluid ſtate, and ſince no plant will live if it be deprived of moiſture, we may conclude that all its food is previouſly diſſolved in water. As for the carbon, we know, that in all active manures it is in ſuch a ſtate of combination, that it is ſoluble in water. We know, too, that all the ſalts which we can ſuppoſe to make a part of the food of plants, are more or leſs ſoluble in water. Lime alſo is ſoluble in water, whether it be pure or in the ſtate of a ſalt; magneſia and alumina may be rendered ſo by means of carbonic acid gas; and Bergman, Macie, and Klaproth, have ſhewn that even ſilica may be diſſolved in water. We can ſee, therefore, in general, though we have no preciſe notions of the very combinations which are immediately imbibed by plants, that all the ſubſtances which form eſſential parts of that food *may* be diſſolved in water.

124 Diſſolved in water.

125 Therefore fluid.

15. Since the food of plants is imbibed by their roots in a fluid ſtate, it muſt exiſt in plants in a fluid ſtate; and unleſs it undergoes alterations in its compoſition juſt when imbibed, we may expect to find it in the plant unaltered. If there were any method of obtaining this fluid food from plants before it has been altered by them, we might analyſe it, and obtain by that means a much more accurate knowledge of the food of plants than we can by any other method. This plan indeed muſt fail, provided the food undergoes alteration juſt when it is abſorbed by the roots: but if we conſider, that when one ſpecies of tree is grafted upon another, each bears its own peculiar fruit, and produces its own peculiar ſubſtances, we can ſcarcely avoid thinking that the *great* changes, at leaſt which the food undergoes after abſorption, are produced, not in the roots, but in other parts of the plant.

126 Sap of plants.

If this concluſion be juſt, the food of plants, after being imbibed by the roots, muſt go directly to thoſe organs where it is to receive new modifications, and to be rendered fit for being aſſimilated to the different parts of the plant. There ought therefore to be certain juices continually aſcending from the roots of plants; and theſe juices, if we could get them pure and unmixed with the other juices or fluids which the plant muſt contain, and which have been ſecreted and formed from theſe primary juices, would be, very nearly at leaſt, the food as it was imbibed by the plant. Now during the vegetation of plants, there actually is a *juice* continually aſcending from their roots. This juice has been called the *ſap*, the *ſuccus communis*, the *lymph* of plants. We ſhall adopt the firſt of theſe names, becauſe it has been moſt generally received.

The firſt ſtep towards an accurate knowledge of the food, and of the changes which take place during vegetation, is an analyſis of the ſap. The ſap is moſt abundant during the ſpring. At that ſeaſon, if a cut be made through the bark and part of the wood of ſome trees, the ſap flows out very profuſely. The trees are then ſaid to *bleed*. By this contrivance any quantity of ſap we think proper may be collected. It is not probable, indeed, that by this method we obtain the aſcending ſap in all its purity: it is no doubt mixed with the peculiar juices of the plant; but the leſs progreſs vegetation has made, the purer we may expect to find it; both becauſe the peculiar juices muſt be in much ſmaller quantity, and becauſe its quantity

may

Vegetation. may be fuppofed to be greater. We fhould therefore examine the fap as early in the feafon as poffible, and at all events before the leaves have expanded.

127 Analyfed. For the moft complete fet of experiments hitherto made upon the fap, we are indebted to Mr Vauquelin. An account of his experiments has been publifhed in the 31ft volume of the *Annales de Chimie*. He has neglected to inform us of the ftate of the tree when the fap which he analyfed was taken from it; fo that we are left in a ftate of uncertainty with refpect to the purity of the fap: but from the comparifon which he has put it in our power to draw between the ftate of the fap at different fucceffive periods, we may in fome meafure obviate this uncertainty.

He found that 1039 parts of the fap of the ulmus campeftris, or common elm, were compofed of

1027.567 water and volatile matter,
9.553 acetite of potafs,
1.062 vegetable matter,
0.818 carbonat of lime,

Befides fome flight traces of fulphuric and muriatic acids.

On analyfing the fame fap fomewhat later in the feafon, Mr Vauquelin found the quantity of vegetable matter a little increafed, and that of the carbonat of lime and acetite of potafs diminifhed. Still later in the feafon the vegetable matter was farther increafed, and the other two ingredients farther diminfhed. The acetite of potafs, in 1039 parts of this third fap, amounted to 8.615 parts *.

If thefe experiments warrant any confequence to be drawn from them, they would induce us to fuppofe that the carbonat of lime and acetite of potafs were contained in the pure afcending fap, and that part at leaft of the vegetable matter was derived from the peculiar juices altered by the fecreting organs of the plant; for the two falts diminifhed in quantity, and the vegetable matter increafed as the vegetation of the tree advanced. Now this is precifely what ought to have taken place, on the fuppofition that the fap became more and more mixed with the peculiar juices of the tree, as we are fuppofing it to do. If thefe conclufions have any folidity, it follows from them, that carbonat of lime and acetite of potafs are abforbed by plants as a part of their food. Now thefe falts, before they are abforbed, muft be diffolved in water. But the carbonat of lime may be diffolved in water by the help of carbonic acid. This fhews us how water faturated with carbonic acid may be ufeful to plants vegetating in a proper foil, while it is ufelefs to thofe that vegetate in pure water. In the pure water there is no carbonat of lime to be diffolved; and therefore carbonic acid gas cannot enter into a combination which renders it proper for becoming the food of plants. Part of the vegetable matter was precipitated from the fap by alcohol. This part feems to have been gummy. Now gums we know are produced by vegetation.

* *Ann. de Chim.* xxxi. 32.

The fap of the fagus fylvatica, or beech, contained the following ingredients.

Water,
Acetite of lime with excefs of acid,
Acetite of potafs,
Gallic acid,
Tan,
A mucous and extractive matter,
Acetite of alumina.

Although Mr Vauquelin made two different analyfes of this fap at different feafons, it is impoffible to draw any fatisfactory conclufions from them, as he has not given us the proportions of the ingredients. It feems clear that the gallic acid and tan were combined together; for the fap tafted like the infufion of oak bark. The quantity of each of thefe ingredients increafed as vegetation advanced; for the colour of the fecond fap collected later was much deeper than that of the firft. This fhews us that thefe ingredients were produced by vegetation, and that they did not form a part of the afcending fap. Probably they were derived from the bark of the tree. The prefence of alumina, and the abfence of carbonic acid gas, would feem to indicate that all plants do not imbibe the very fame food.

The fap of the capinus fylveftris contains water, acetite of potafs, acetite of lime, fugar, mucilage, vegetable extract. It cannot be doubted that the fugar and the mucilage are the produce of vegetation.

The fap of the betula alba, or common birch, contains water, fugar, vegetable extract, acetite of lime, acetite of alumina, and acetite of potafs.

Thefe experiments are curious, and certainly add to the precifion of our notions concerning the food of plants; but they are not decifive enough to entitle us to draw conclufions. They would feem to fhew, either that acetite of potafs and lime are a part of the food of plants, or at leaft fome fubftances which have the property of affuming thefe combinations.

16. Thefe experiments lead to the conclufion that acetous acid forms a component part of the fap. Now it is not eafy to fuppofe that this fubftance is actually abforbed by the roots in the ftate of acetous acid. The thing might be determined by examining the mould in which plants grow. This examination indeed has been performed; but no chemift has ever found acetous acid, at leaft in any fenfible quantity. Is it not probable, then, that the food, after it is imbibed, is fomewhat modified and altered by the roots? In what manner this is done we cannot fay, as we know very little about the vafcular ftructure of the roots. We may conclude, however, that this modification is nearly the fame in moft plants: for one plant may be engrafted on another, and each continue to produce its own peculiar products; which could not be, unlefs the proper fubftances were conveyed to the digeftive organs of all. There are feveral circumftances, however, which render the modifying power of the roots fomewhat probable. The ftrongeft of thefe is the nature of the ingredients found in the fap. It is even poffible that the roots may, by fome means or other, throw out again fome part of the food which they have imbibed as excrementitious. This has been fufpected by feveral phyfiologifts; and there are feveral circumftances which render it probable. It it well known that fome plants will not vegetate well after others; and that fome again vegetate unufually well when planted in ground where certain plants had been growing. Thefe facts, without doubt, may be accounted for on other principles. If there be any excrementitious matter emitted by the roots, it is much more probable that this happens in the laft ftage of vegetation. That is to fay, when the food, after digeftion, is applied to the purpofes which the root requires. But the fact ought to be fupported by experiments, otherwife it cannot be admitted.

128 Whether the food is altered by the roots.

17. The

Vegetation.

17. The ſap, as Dr Hales has ſhewn us, aſcends with a very conſiderable force. It iſſued during the bleeding ſeaſon with ſuch impetuoſity from the cut end of a vine branch, that it ſupported a column of mercury $32\frac{1}{2}$ inches high *.

* Veg. Stat. 105.

129
Sap aſcends

Now what is the particular channel through which the ſap aſcends, and what is the cauſe of the force with which it moves? Theſe are queſtions which have excited a great deal of the attention of thoſe philoſophers who have made the phyſiology of vegetables their particular ſtudy; but the examination of them is attended with ſo many difficulties that they are very far from being decided.

It is certain that the ſap flows from the roots towards the ſummit of the tree. For if in the bleeding ſeaſon a number of openings be made in the tree, the ſap begins firſt to flow from the loweſt opening, then from the loweſt but one, and ſo on ſucceſſively, till at laſt it makes its appearance at the higheſt of all. And when Duhamel and Bonnet made plants vegetate in coloured liquors, the colouring matter, which was depoſited in the wood, appeared firſt in the loweſt part of the tree, and gradually aſcended higher and higher, till at laſt it reached the top of the tree, and tinged the very leaves.

130
Through the wood.

It ſeems certain, too, that the ſap aſcends through the wood, and not through the bark of the tree: for a plant continues to grow even when ſtript of a great part of its bark; which could not happen if the ſap aſcended through the bark. When an inciſion, deep enough to penetrate the bark, and even part of the wood, is carried quite round a branch, provided the wound be covered up from the external air, the branch continues to vegetate as if nothing had happened; which could not be the caſe if the ſap aſcended between the bark and the wood. It is well known, too, that in the bleeding ſeaſon little or no ſap can be goot from a tree unleſs our inciſion penetrate deeper than the bark.

131
Not by the parenchyma;

If the ſap aſcended thro' the parenchyma of plants, as ſome phyſiologiſts have ſuppoſed, ſince there is a communication between every part of that organ, it is evident that the tree ought to bleed whenever any part of the parenchyma is wounded. But this is not the caſe. Conſequently the ſap does not aſcend through the parenchyma. Beſides, if the ſuppoſition were true, the ſap, from the very ſtructure of the parenchyma, muſt aſcend in the ſame manner as water through a ſponge; and in that caſe could not poſſibly poſſeſs the force with which we know that it aſcends. But if the ſap is not found in the parenchyma, as is now well known to be the caſe, it muſt, of neceſſity, be confined in particular veſſels; for if it were not, it would undoubtedly make its appearance there. Now what are the veſſels through which the ſap aſcends?

132
But in veſſels.

Grew and Malpighi, the firſt philoſophers who examined the ſtructure of plants, took it for granted that the woody fibres were tubes, and that the ſap aſcended through them. For this reaſon they gave theſe fibres the name of *lymphatic* veſſels. But they were unable, even when aſſiſted by the beſt microſcopes, to detect any thing in theſe fibres which had the appearance of a tube; and ſucceeding obſervers have been equally unſucceſsful. The conjecture therefore of Malpighi and Grew, about the nature and uſe of theſe fibres, remains totally unſupported by any proof. Duhamel has even gone far to overturn it altogether. For he found that theſe woody fibres are diviſible into ſmaller fibres, and theſe again into ſtill ſmaller; and even, by the aſſiſtance of the beſt microſcopes, he could find no end of this ſubdiviſion *. Now granting theſe fibres to be veſſels, it is ſcarcely poſſible, after this, to ſuppoſe that the ſap really moves through tubes, whoſe diameters are almoſt infinitely ſmall. There are, however, veſſels in plants which may eaſily be diſtinguiſhed by the help of a ſmall microſcope, and even, in many caſes, by the naked eye. Theſe were ſeen, and diſtinctly deſcribed, by Grew and Malpighi. They conſiſt of a fibre twiſted round like a corkſcrew. If we take a ſmall cylinder of wood, and wrap round it a ſlender braſs wire, ſo cloſely that all the rings of the wire touch each other, and if, after this, we pull out the wooden cylinder altogether, the braſs wire thus twiſted will give us a very good repreſentation of theſe veſſels. If we take hold of the two ends of the braſs wire thus twiſted, and pull them, we can eaſily draw out the wire to a conſiderable length. In the ſame manner, when we lay hold of the two extremities of theſe veſſels, we can draw them out to a great length. Malpighi and Grew finding them always empty, concluded that they were intended for the circulation of the air through the plant, and therefore gave them the name of *tracheæ*; which word is uſed to denote the *windpipe* of animals. Theſe *tracheæ* are not found in the bark; but Hedwig has ſhewn that they are much more numerous in the wood than was ſuppoſed; and that they are of very different diameters; and Reichel has demonſtrated that they go to the minuteſt branches, and ſpread through every leaf. He has ſhewn, too, that they contain ſap; and Hedwig has proved that the notion which generally prevailed of their containing nothing but air, aroſe from this circumſtance, that the larger tracheæ, which alone were attended to, loſe their ſap as ſoon as they are cut; and, of courſe, unleſs they are inſpected the inſtant they are divided, they appear empty †. Is it not probable, then, or rather is it not certain, from the diſcoveries of that very ingenious phyſiologiſt, that the tracheæ are, in reality, the ſap veſſels of plants? Indeed it ſeems eſtabliſhed by the experiments both of Reichel and Hedwig, that all, or almoſt all the veſſels of plants may, if we attend only to their ſtructure, be denominated *tracheæ*.

* *Phyſique des Arbres*, i. 57.

† *Fundament. Hiſt. Nat. Muſcor. Frondos.* Part i. p. 54.

133
Why it aſcends.

But by what powers is the ſap made to aſcend in theſe veſſels? And not only to aſcend, but to move with very conſiderable force; a force, as Hales has ſhewn, ſufficient to overcome the preſſure of 43 feet perpendicular of water ‡?

‡ *Veget. Stat.* i. 107.

134
Hypotheſes of Grew, Malpighi, and de la Hire.

Grew aſcribed this phenomenon to the levity of the ſap; which, according to him, entered the plant in the ſtate of a very light vapour. But this opinion will not bear the ſlighteſt examination. Malpighi ſuppoſed that the ſap was made to aſcend by the contraction and dilation of the air contained in the air veſſels. But even were we to grant that the tracheæ are air veſſels, the ſap, according to this hypotheſis, could only aſcend when a change of temperature takes place; which is contrary to fact. And even if we were to wave every objection of that kind, the hypotheſis would not account for the circulation of the ſap, unleſs the ſap veſſels be provided with valves. Now the experiments of Hales and Duhamel ſhew that no valves can poſſibly exiſt in them. For branches imbibe moiſture nearly equally

equally by either end; and conſequently the ſap moves with equal facility both upwards and downwards, which it could not do were there valves in the veſſels. Beſides, it is known, from many experiments, that we may convert the roots of a tree into the branches, and the branches into the roots, by covering the branches with earth, and expoſing the roots to the air. Now this would be impoſſible if the ſap veſſels were provided with valves. The ſame remarks overturn the hypotheſis of Mr de la Hire, which is merely that of Malpighi, expreſſed with greater preciſion, and with a greater parade of mechanical knowledge. Like Borelli, he placed the aſcending power of the ſap in the parenchyma. But his very experiments, had he attended to them with care, would have been ſufficient to ſhew the imperfection of his theory.

The greater number of philoſophers (for it is needleſs to mention thoſe who, like Perrault, had recourſe to fermentation, nor thoſe who introduced the weight of the atmoſphere) have aſcribed the motion of the ſap to *capillary attraction.*

135 Aſcribed to capillary attraction.

There exiſts a certain attraction between many ſolid bodies and liquids; in conſequence of which, if theſe ſolid bodies be formed into ſmall tubes, the liquid enters them, and riſes in them to a certain height. But this is perceptible only when the diameter of the tube is very ſmall. Hence the attraction has been denominated *capillary.* We know that there is ſuch an attraction between vegetable fibres and watery liquids. For ſuch liquids will aſcend through dead vegetable matter. It is highly probable, therefore, that the food of plants enters the roots, in conſequence of the capillary attraction which ſubſiſts between the ſap veſſels and the liquid imbibed. This ſpecies of attraction, then, will account perfectly well for the entrance of moiſture into the mouths of the ſap veſſels. But will it account alſo, as ſome have ſuppoſed, for the aſcent of the ſap, and for the great force with which it aſcends?

136 This opinion examined;

The nature and laws of capillary attraction have been very much overlooked by philoſophers. But we know enough concerning it to enable us to decide the preſent queſtion. It conſiſts in a certain attraction between the particles of the liquid and of the tube. It has been demonſtrated, that it does not extend, or at leaſt that it produces no ſenſible effect, at greater diſtances than $\frac{1}{1000}$th part of an inch. It has been demonſtrated, that the water aſcends, not by the capillary attraction of the whole tube, but of a ſlender film of it; and Clairaut has ſhewn that this film is ſituated at the lowermoſt extremity of the tube (G). This film attracts the liquid with a certain force; and if this force be greater than the coheſion between the particles of the liquid, part enters the tube, and continues to enter, till the quantity above the attracting film of the tube juſt equals, by its weight, the exceſs of the capillary attraction between the tube and the liquid, above the coheſion of the liquid. The quantity of water therefore in the tube is pretty nearly the meaſure of this exceſs; for the attracting film is probably very minute.

It has been demonſtrated, that the heights to which liquids riſe in capillary tubes, are inverſely as the diameter of the tube. Conſequently the ſmaller the diameter of the tube, the greater is the height to which the liquid will riſe. But the particles of water are not infinitely ſmall; therefore whenever the diameter of the tube is diminiſhed beyond a certain ſize, water cannot aſcend in it, becauſe its particles are now larger than the bore of the tube. Conſequently the riſe of water in capillary tubes muſt have a limit: if they exceed a certain length, how ſmall ſoever their bore may be, water will either not riſe to the top of them, or it will not enter them at all. We have no method of aſcertaining the preciſe height to which water would riſe in a capillary tube, whoſe bore is juſt large enough to admit a ſingle particle of water. Therefore we do not know the limit of the height to which water may be raiſed by capillary attraction. But whenever the bore is diminiſhed beyond a certain ſize, the quantity of water which riſes in it is too ſmall to be ſenſible. We can eaſily aſcertain the height which water cannot exceed in capillary tubes before this happens; and if any perſon calculate, he will find that this height is not nearly equal to the length of the ſap veſſels of many plants. But beſides all this, we ſee in many plants very long ſap veſſels, of a diameter too large for a liquid to riſe in them a ſingle foot by capillary attraction, and yet the ſap riſes in them to very great heights.

If any perſon ſays that the ſap veſſels of plants gradually diminiſh in diameter as they aſcend; and that, in conſequence of this contrivance, they act preciſely as an indefinite number of capillary tubes, one ſtanding upon another, the inferior ſerving as a reſervoir for the ſuperior: we anſwer, that the ſap may aſcend by that means to a conſiderable height; but certainly not in any greater quantity than if the whole ſap veſſel had been preciſely of the bore of its upper extremity. For the quantity of ſap raiſed muſt depend upon the bore of the upper extremity, becauſe it muſt all paſs through that extremity. The quantity of ſap, too, on that ſuppoſition, muſt diminiſh the farther we go from the root, becauſe the bore of the ſap veſſels is conſtantly diminiſhing; the aſcending force muſt alſo diminiſh, becauſe it is, in all caſes, proportional to the quantity of water raiſed. Now neither of theſe, as Dr Hales has demonſtrated, is true.

137 And refuted.

But farther, if the ſap moved only in the veſſels of plants by capillary attraction, it would be ſo far from flowing out at the extremity of a branch, with a force ſufficient to overcome the preſſure of a column of water 43 feet high, that it could not flow out at all. It would be impoſſible in that caſe for any ſuch thing as the bleeding of trees ever to happen.

If we take a capillary tube, of ſuch a bore that a liquid will riſe in it ſix inches, and after the liquid has riſen to its greateſt height, break it ſhort three inches from the bottom, none of the liquid in the under half flows over. The tube, thus ſhortened, continues indeed full, but not a ſingle particle of liquid ever eſcapes from it. And how is it poſſible for it to eſcape? The film,

(G) The action of all the other films, of which the tube is compoſed, on the water, as far as it is meaſured by its effect, is nothing at all. For every particle of water in the tube (except thoſe attracted by the undermoſt film) is attracted upwards and downwards by the ſame number of films: it is therefore preciſely in the ſame ſtate as if it were not attracted at all.

Vegeta-tion film, at the *upper* extremity of the tube, must certainly have as strong an attraction for the liquid as the film at the *lower* extremity. As part of the liquid is within its attracting distance, and as there is no part of the tube above to counterbalance this attraction, it must of necessity attract the liquid nearest it, and with a force sufficient to counterbalance the attraction of the undermost film, how great soever we may suppose it. Of course no liquid can be forced up, and consequently none can flow out of the tube. Since then the sap *flows out* at the upper extremity of the sap vessels of plants, we are absolutely certain that it does not ascend in them merely by its capillary attraction, but that there is some other cause.

It is impossible therefore to account for the motion of the sap in plants by any mechanical or chemical principles whatever; and he who ascribes it to these principles has not formed to himself any clear or accurate conception of the subject. We know indeed that heat is an agent; for Dr Walker found that the ascent of the sap is much promoted by heat, and that after it had begun to flow from several incisions, cold made it give over flowing from the higher orifices while it continued to flow at the lower *. But this cannot be owing to the dilating power of heat; for unless the sap vessels of plants were furnished with valves (and they have no valves), dilatation would rather retard than promote the ascent of the sap. Consequently the effect of heat can give us no assistance in explaining the ascent of the sap upon mechanical and chemical principles.

* Edin. Tranf. i.

138 The vessels must contract,

We must therefore ascribe it to some other cause: the vessels themselves must certainly act. Many philosophers have seen the necessity of this, and have accordingly ascribed the ascent of the sap to *irritability*. But the first person who gave a precise view of the manner in which the vessels probably act was Saussure. He supposes that the sap enters the open mouths of the vessels, at the extremity of the roots; that these mouths then contract, and by that contraction propel the sap upwards; that this contraction gradually follows the sap, pushing it up from the extremity of the root to the summit of the plant. In the mean time the mouths are receiving new sap, which in the same manner is pushed upwards †. Whether we suppose the contraction to take place precisely in this manner or not, we can scarcely deny that it must take place; but by what means it is impossible to say. The agents cannot precisely resemble the muscles of animals; because the whole tube, however cut or maimed, still retains its contracting power, and because the contraction is performed with equal readiness in every direction. It is evident, however, that they must be the same in kind. Perhaps the particular structure of the vessels may fit them for their office. Does ring after ring contract its diameter? The contracting agents, whatever they are, seem to be excited to act by some stimulus communicated to them by the sap. This capacity of being excited to action is known in physiology by the name of *irritability*; and there are not wanting proofs that plants are possessed of it. It is well known that different parts of plants move when certain substances act upon them. Thus the flowers of many plants open at sunrise, and close again at night. Linnæus has given us a list of these plants. Des Fontaines has shewn that the stamina and antheræ of many plants exhibit distinct motions ‡. Dr Smith has observed, that the stamina of the barberries are thrown into motions when touched §. Roth has ascertained that the leaves of the drosera longifolia and rotundifolia have the same property. Mr Coulon, too, who has adopted the opinion that the motion of the sap in plants is produced by the contraction of vessels, has even made a number of experiments in order to shew this contraction. But the fact is, that every one has it in his power to make a decisive experiment. Simply cutting a plant, the *euphorbia peplis* for instance, in two places, so as to separate a portion of the stem from the rest, is a complete demonstration that the vessels actually do contract. For whoever makes the experiment, will find that the milky juice of that plant flows out at both ends so completely, that if afterwards we cut the portion of the stem in the middle, no juice whatever appears. Now it is impossible that these phenomena could take place without a contraction of the vessels; for the vessels in that part of the stem which has been detached cannot have been *more* than full; and their diameter is so small, that if it were to continue unaltered, the capillary attraction would be more than sufficient to retain their contents, and consequently not a drop could flow out. Since, therefore, the whole liquid escapes, it must be driven out forcibly, and consequently the vessels must contract.

† Encyc. Meth. Phyf. Art. p.

‡ Mem. Par. 1787. § Phil. Tranf. lxxviii.

It seems pretty plain, too, that the vessels are excited to contract by various stimuli; the experiments of Coulon and Saussure render this probable, and an observation of Dr Smith Barton makes it pretty certain. He found that plants growing in water vegetated with much greater vigour, provided a little camphor was thrown into the water *. 139 In consequence of stimuli.

* Ann. de Chim. xxiii. 63.

18. Besides the sap which ascends upwards towards the leaves, they contain also another fluid, known by the name of *succus proprius*, or *peculiar juice*. This juice differs very considerably in different plants. It seems to be the sap altered by some process or other, and fitted for the various purposes of vegetation. That it flows from the leaves of the plant towards the roots, appears from this circumstance, that when we make an incision into a plant, into what ever position we put it, much more of the succus proprius flows from that side of the wound which is next the leaves and branches, than from the other side: and this happens even though the leaves and branches be held undermost †. When a ligature is tied about a plant, a swelling appears above, but not below the ligature. 140 Peculiar juice formed from the sap;

† Bell, Manch. Mem. ii. 402.

The vessels containing the peculiar juice are found in all the parts of the plant. Hedwig, who has examined the vessels of plants with very great care, seems to consider them as of the same structure with the tracheæ. The peculiar juice is easily known by its colour and its consistence. In some plants it is green, in some red, in many milky. It cannot be doubted that its motion in the vessels is performed in the same way as that of the sap.

19. It appears, then, that the sap ascends to the leaves, that there it undergoes certain alterations, and is converted into the peculiar juices; which, like the blood in animals, are afterwards employed in forming the various substances found in plants. Now the changes which the sap undergoes in the leaves, provided we can trace them, must throw a great deal of light upon the nature of vegetation. 141 In the leaves.

Vegetation.

142 Part of the ſap perſpires thro' the leaves.

No ſooner has the ſap arrived at the leaves, than a great part of it is thrown off by evaporation. The quantity thus perſpired bears a very great proportion to the moiſture imbibed. Mr Woodward found that a ſprig of mint in 77 days imbibed 2558 grains of water, and yet its weight was only increaſed 15 grains *: therefore it muſt have given out 2543 grains. Another branch, which weighed 127 grains, increaſed in weight 128, and it had imbibed 14190 grains. Another ſprig, weighing 76 grains, growing in water mixed with earth, increaſed in weight 168 grains, and had imbibed 10731 grains of water. Theſe experiments demonſtrate the great quantity of matter which is conſtantly leaving the plant. Dr Hales found that a cabbage tranſmitted daily a quantity of moiſture equal to about half its weight; and that a ſun-flower, three feet high, tranſmitted in a day 1 lb. 14 oz. avoirdupois †. He ſhewed, that the quantity of tranſpiration in the ſame plant was proportional to the ſurface of the leaves, and that when the leaves were taken off, the tranſpiration nearly ceaſed ‡. By theſe obſervations, he demonſtrated that the leaves are the organs of tranſpiration. He found, too, that the tranſpiration was nearly confined to the day, very little taking place during the night §; that it was much promoted by heat, and ſtopped by rain and froſt ||. And Millar ¶, Guettard *, and Senebier, have ſhewn that the tranſpiration is alſo very much promoted by ſunſhine.

* *Phil. Tranſ.* No. 253.
† *Veget. Stat.* i. 5. and 15.
‡ *Ibid.* 30.
§ *Ibid.* 5.
|| *Ibid.* 27. and 48.
¶ *Ibid.* 22.
* *Mem. Par.* 1748.

The quantity of moiſture imbibed by plants depends very much upon what they tranſpire. The reaſon is evident: when the veſſels are once filled with ſap, if none be carried off, no more can enter; and, of courſe, the quantity which enters muſt depend upon the quantity emitted.

In order to diſcover the nature of the tranſpired matter, Hales placed plants in large glaſs veſſels, and by that means collected a quantity of it †. He found that it reſembled pure water in every particular, excepting only that it ſometimes had the odour of the plant. He remarked, too, as Guettard and Du Hamel did after him, that when kept for ſome time it putrefied, or at leaſt acquired a ſtinking ſmell. Senebier ſubjected a quantity of this liquid to a chemical analyſis.

† *Ibid.* 49.

143 Its nature,

He collected 13030 grains of it from a vine during the months of May and June. After filtration he gradually evaporated the whole to dryneſs. There remained behind two grains of reſiduum. Theſe two grains conſiſted of nearly ½ grain of carbonat of lime, $\frac{1}{11}$ grain of ſulphat of lime, ½ grain of matter ſoluble in water, and having the appearance of gum, and ½ grain of matter which was ſoluble in alcohol, and apparently reſinous. He analyzed 6c768 grains of the ſame liquid, collected from the vine during the months of July and Auguſt. On evaporation he obtained $2\frac{1}{8}$ grains of reſiduum, compoſed of ¾ grain of carbonat of lime, ¼ grain of ſulphat of lime, ½ grain of mucilage, and ½ grain of reſin. The liquid tranſpired by the *aſter novæ Angliæ* afforded preciſely the ſame ingredients ‡.

‡ *Enc. Meth. Phyſ. Veget.* 287.

144 And quantity.

Senebier attempted to aſcertain the proportion which the liquid tranſpired bore to the quantity of moiſture imbibed by the plant. But it is eaſy to ſee that ſuch experiments are liable to too great uncertainties to be depended on. His method was as follows: He plunged the thick end of the branch on which he made the experiment into a bottle of water, while the other end, containing all its leaves, was thruſt into a very large glaſs globe. The apparatus was then expoſed to the ſunſhine. The quantity imbibed was known exactly by the water which diſappeared from the bottle, and the quantity tranſpired was judged of by the liquid which condenſed and trickled down the ſides of the glaſs globe. The following table exhibits the reſult of his experiments:

Plants.	*Imbibed.*	*Perſpired.*	*Time.*
Peach	100 gr.	35 gr.	
Ditto	210	90	
Ditto	220	120	
Mint	200	90	2 days.
Ditto	575	120	10
Raſp	725	560	2
Ditto	1232	765	2
Peach	710	295	1
Apricot	210	180	1

In ſome of his experiments no liquid at all was condenſed. Hence it is evident that the quantity of matter tranſpired cannot be deduced from theſe experiments. The mouth of the glaſs globe does not ſeem to have been accurately cloſed; the air within it communicated with the external air: conſequently the quantity condenſed muſt have depended entirely upon the ſtate of the external air, the heat, &c.

The firſt great change, then, which takes place upon the ſap after it arrives at the leaves, is the evaporation of a great part of it: conſequently what remains muſt be very different in its proportions from the ſap. The leaves ſeem to have particular organs adapted for throwing off part of the ſap by tranſpiration. For the experiments of Guettard *, Duhamel †, and Bonnet ‡, ſhew that it is performed chiefly by the upper ſurfaces of leaves, and may be nearly ſtopped altogether by varniſhing the upper ſurface.

* *Mem. Par.* 1749.
† *Phyſique des Arbres*, i. 158.
‡ *Traité des Feuilles*, i. *Mem.*

145 Why the leaves fall off.

The leaves of plants become gradually leſs and leſs fit for this tranſpiration; for Senebier found, that when all other things are equal, the tranſpiration is much greater in May than in September *. Hence the reaſon that the leaves are renewed annually. Their organs become gradually unfit for performing their functions, and therefore it is neceſſary to renew them. Thoſe trees which retain their leaves during the winter were found by Hales and ſucceeding phyſiologiſts to tranſpire leſs than others. It is now well known that theſe trees alſo renew their leaves.

* *Enc. Method. Veget.* 285.

20. Leaves have alſo the property of abſorbing carbonic acid gas from the atmoſphere.

146 Leaves abſorb carbonic acid gas.

We are indebted for this very ſingular diſcovery to the experiments of Dr Prieſtley, though he himſelf did not diſcover the truth, and though he even refuſed to acknowledge it when it was pointed out by others. It has been long known, that when a candle has been allowed to burn out in any quantity of air, no candle can afterwards be made to burn in it. In the year 1771 Dr Prieſtley made a ſprig of mint vegetate for ten days in contact with a quantity of ſuch air; after which he found that a candle would burn in it perfectly well ¶. This experiment he repeated frequently, and found that it was always attended with the ſame reſult. According to the opinion at that time univerſally received, that the

¶ *On Air*, iii. 251.

Vegetation. the burning of candles rendered air impure by communicating phlogiston to it, he concluded from it, that plants, while they vegetate, absorb phlogiston.

Carbonic acid gas was at that time supposed to contain phlogiston. It was natural, therefore, to suppose that it would afford nourishment to plants, since they had the property of absorbing phlogiston from the atmosphere. Dr Percival had published a set of experiments; by which he endeavoured to shew that this was actually the case.

These experiments induced Dr Priestley, in 1776, to consider the subject with more attention. But as, in all the experiments which he made, the plants confined in carbonic acid gas very soon died, he concluded that carbonic acid gas was not a food, but a poison to plants *. Mr Henry of Manchester was led, in 1784, probably by the contrariety of these results, to examine the subject. His experiments, which were published in the Manchester Transactions †, perfectly coincided with those of Dr Percival. For he found, that carbonic acid gas, so far from killing plants, constantly promoted their growth and vigour. Meanwhile Mr Senebier was occupied at Geneva with the same subject; and he published the result of his researches in his *Memoires Physico-chymique* about the year 1780. His experiments shewed, in the clearest manner, that carbonic acid gas is used by plants as food. The same thing was supported by Ingenhousz in his second volume. The experiments of Saussure the Son, published in 1797, have at last put the subject beyond the reach of dispute. From a careful comparison of the experiments of these philosophers, it will not be difficult for us to discover the various phenomena, and to reconcile all the seeming contradictions which occur in them. The facts are as follows:

* On Air, 100.

† ii. 341.

Mr Saussure has shewn, that plants will not vegetate when totally deprived of carbonic acid gas. They vegetate indeed well enough in air which has been previously deprived of carbonic acid gas; but when a quantity of lime was put into the glass vessel which contained them, they no longer continued to grow, and the leaves in a few days fell off ‡. The air, when examined, was found to contain no carbonic acid gas. The reason of this phenomenon is, that plants (as we shall see afterwards) have the power of forming and giving out carbonic acid in certain circumstances; and this quantity is sufficient to continue their vegetation for a certain time. But if this new formed gas be also withdrawn, by quicklime, for instance, which absorbs it the instant it appears, the leaves droop, and refuse to perform their functions. Carbonic acid gas, then, applied to the leaves of plants, is *essential* to vegetation.

‡ Ann. de Chim xxiv. 145. 148.

147 Decompose it, and emit the oxygen;

Dr Priestley, to whom we are indebted for many of the most important facts relative to vegetation, observed, in the year 1778, that plants, in certain circumstances, emitted oxygen gas ‖; and Ingenhousz very soon after discovered that this gas is emitted by the *leaves* of plants, and only when they are exposed to the bright light of day. His method was to plunge the leaves of different plants into vessels full of water, and then expose them to the sun, as Bonnet, who had observed the same phenomenon, though he had given a wrong explanation of it, had done before him. Bubbles of oxygen gas very soon detached themselves from the leaves, and were collected in an inverted glass vessel *. He observed, too, that it was not a matter of indifference what kind of water was used. If the water, for instance, had been previously boiled, little or no oxygen gas escaped from the leaves; river water afforded but little gas; but pump water was the most productive of all †.

‖ On Air, iii. 284.

* Ingenhousz on Veget. i. 15. &c.

† Ibid. 83.

Senebier proved, that if the water be previously deprived of all its air by boiling, the leaves do not emit a particle of air; that those kinds of water which yield most air, contain in them the greatest quantity of carbonic acid gas; that leaves do not yield any oxygen when plunged in water totally destitute of carbonic acid gas; that they emit it abundantly when the water, rendered unproductive by boiling, is impregnated with carbonic acid gas; that the quantity of oxygen emitted, and even its purity, is proportional to the quantity of carbonic acid gas which the water contains; that water impregnated with carbonic acid gas gradually loses the property of affording oxygen gas with leaves; and that whenever this happens, all the carbonic acid gas has disappeared; and on adding more carbonic acid gas the property is renewed ‡. These experiments prove, in a most satisfactory manner, that the oxygen gas which the leaves of plants emit depends upon the presence of carbonic acid gas; that the leaves absorb carbonic acid gas, decompose it, give out the oxygen, and retain the carbon.

‡ Enc. Method. Phys. Veget. 181.

148 But during the day only.

We now see why plants will not vegetate without carbonic acid gas. They absorb it and decompose it; but this process goes on only when the plants are exposed to the light of day. Therefore we may conclude, that the absorption and decomposition of carbonic acid gas is confined to the day, and that light is an essential agent in the decomposition. Probably it is by its agency, or by its entering into combination with the oxygen, that this substance is enabled to assume the gaseous form, and to separate from the carbon.

If we reason from analogy, we shall conclude, that during this process a quantity of caloric is necessary; and that therefore no increase of temperature takes place, but rather the contrary. This may be one reason why the operation takes place only during the day.

149 In this way plants may acquire much carbon.

It is extremely probable that plants by this process acquire the greatest part of the carbonaceous matter which they contain; for if we compare the quantity of carbon contained in plants vegetating in the dark, where this process cannot go on, with the quantity which those plants contain which vegetate in the usual manner, we shall perceive a very conspicuous difference. Chaptal found that a byssus, which was vegetating in the dark, contained only $\frac{1}{80}$ of its weight of carbonaceous matter; but the same plant, after being made to vegetate in the light for 30 days, contained $\frac{1}{12}$th of its weight of carbonaceous matter *. Hassenfratz ascertained, that plants growing in the dark contain much more water, and much less carbon and hydrogen, than plants growing in the light. Senebier analysed both with the same result. Plants growing in the dark yielded less hydrogen gas and oil: their resinous matter was to that of plants growing in the light as 2 to 5,5, and their moisture as 13 to 6; they contain even one-half less of fixed matters.

* Mem. Par. 1786.

It is evident, however, that this absorption and decomposition of carbonic acid gas does not depend upon the

Vegetation.

the light alone. The nature of the sap has also it's influence; for Hassenfratz found, that the quantity of carbon did not increase when plants vegetated in pure water. Here the sap seems to have wanted that part which combines with and retains the carbon; and which therefore is by far the most important part of the food of plants. Upon the discovery and mode of applying this substance, whatever it is, the improvements in agriculture must in a great measure depend.

If we consider the difference in the proportion of carbonaceous matter in plants vegetating in the dark and in the usual manner, we can scarcely avoid concluding that the quantity of carbonic acid gas absorbed by plants is considerable. To form an estimate of it, would require a set of experiments performed in a very different manner from any hitherto made. The stems and branches of plants vegetating in a rich soil should be confined within a large glass globe, the inside of which ought to have no communication with the external air. A very small stream of carbonic acid gas should be made occasionally to flow into this globe, so as to supply the quantity that may appear necessary; and there should be a contrivance to carry off and examine the air within the globe when it increases beyond a certain quantity. Experiments conducted in this manner would probably throw a great deal of light upon this part of vegetation, and enable us to calculate the quantity of carbonic acid decomposed, and the quantity of oxygen emitted by plants; to compare these with the waste of oxygen by the respiration of animals and combustion, and to see whether or not they balance each other.

150 The decomposition performed by the parenchyma.

Senebier has ascertained, that the decomposition of the carbonic acid takes place in the parenchyma. He found, that the epidermis of a leaf would, when separated, give out no air, neither would the nerves in the same circumstances; but upon trying the parenchyma, thus separated from its epidermis and part of its nerves, it continued to give out oxygen as before †. He remarked also, that every thing else being equal, the quantity of oxygen emitted, and consequently of carbonic acid decomposed, is proportional to the thickness of the leaf; and this thickness depends upon the quantity of parenchyma.

† *Enc. Method Phys. Veget.* 180.

That the decomposition is performed by peculiar organs, is evident from an experiment of Ingenhousz. Leaves cut into small pieces continued to give out oxygen as before; but leaves pounded in a mortar lost the property entirely. In the first state, the peculiar structure remained; in the other, it was destroyed. Certain experiments of Count Rumford, indeed, are totally incompatible with this conclusion; and they will naturally occur to the reader as an unsurmountable objection. He found, that dried leaves, black poplar, fibres of raw silk, and even glass, when plunged into water, gave out oxygen gas by the light of the sun. But when Senebier repeated these experiments, not one of them would succeed ‡; and we have attempted them with the same bad success. The Count must have been misled by something which he has not mentioned.

‡ *Ann. de Chim.* i. 115.

Thus we have seen, that when the sap arrives at the leaves, great part is thrown off by evaporation, and that the nature of the remainder is considerably altered by the addition of a quantity of carbon: but these are by no means all the alterations produced upon the sap in the leaves.

151 Leaves absorb oxygen,

21. Plants will not vegetate unless atmospheric air or oxygen gas have access to their leaves. This was rendered probable by those philosophers who, about the end of the 17th century, turned their attention particularly towards the physical properties of the air: But Mr Ingenhousz was perhaps the first of the modern chemists who put it beyond doubt. He found that carbonic acid gas, azot, and hydrogen gas, destroyed plants altogether, unless they were mixed with atmospheric air or oxygen gas. He found also, that plants grew very well in oxygen gas and in atmospheric air *. These experiments are sufficient to shew, that oxygen gas is necessary to vegetation. The leaves of plants seem to absorb it; and most probably this absorption takes place only in the night. We know, at least, that in germination light is injurious to the absorption of oxygen gas; and therefore it is probable that this is the case also in vegetation.

* *Ingenhousz* i. passim.

152 And water,

22. The leaves of plants not only absorb carbonic acid gas and oxygen gas, but water also. This had been suspected in all ages: the great effect which dew, slight showers, and even wetting the leaves of plants, have in recruiting their strength, and making them vegetate with vigour, are so many proofs that the leaves imbibe moisture from the atmosphere. Hales rendered this still more probable, by observing, that plants increase considerably in weight when the atmosphere is moist; and Mr Bonnet put the matter beyond doubt in his *Researches concerning the Use of the Leaves.* He shewed, that leaves continue to live for weeks when one of their surfaces is applied to water; and that they not only vegetate themselves, but even imbibe enough of water to support the vegetation of a whole branch, and the leaves belonging to it. He discovered also, that the two surfaces of leaves differ very considerably in their power of imbibing moisture; that in trees and shrubs, the under surface possesses almost the whole of the property, while the contrary holds in many of the other plants; the kidney bean for instance.

These facts prove, not only that the leaves of plants have the power of absorbing moisture, but also that the absorption is performed by very different organs from those which emit moisture; for these organs lie on different sides of the leaf. If we consider that it is only during the night that the leaves of plants are moistened with dew, we can scarcely avoid concluding, that, except in particular cases, it is during the night that plants imbibe almost all the moisture which they do imbibe.

153 And emit carbonic acid gas.

23. During the night the leaves of plants emit carbonic acid gas. This fact was first demonstrated by Mr Ingenhousz †, and it has been since confirmed by every philosopher who has attended to the subject.

† *On Vegetables,* i. 47. and ii. passim.

Thus we have seen that the leaves of plants perform very different operations at different times. During the day they are giving out moisture, absorbing carbonic acid gas, and emitting oxygen gas; during the night, on the contrary, they are absorbing moisture, giving out carbonic acid gas, and absorbing oxygen gas.

The emission of the carbonic acid gas seems to be the consequence of the decomposition of water; either of the water which is already contained in the sap, or of

Vegetation.

of that which the leaves imbibe during the night; but which of the two, it is impossible to determine, nor is it of much consequence. We may conclude that this is the case, because it takes place during the germination of the seed, where all the circumstances seem to be perfectly analogous. The water is decomposed, its oxygen is combined with part of the carbon which had been absorbed during the day, and the hydrogen enters into new combinations in the sap. It appears, also, that this decomposition of water depends in a good measure upon the quantity of oxygen gas absorbed; for Dr Ingenhousz found, that when plants are confined in oxygen gas, they emit more carbonic acid gas than when they are confined in common air †.

† Ingenhousz,

154
Sap converted by these processes into the peculiar juice.

To describe in what manner these decompositions take place, is impossible; because we neither know precisely the substances into which the sap has been converted by the operations performed during the day, nor the new substances formed by the operations of the night. We only see the elementary substances which are added and subtracted; which is far from being sufficient to give us precise notions concerning the chemical changes and the affinities by which these changes are produced. We have reason, however, to conclude, that during the day the carbon of the sap is increased, and that during the night the hydrogen and oxygen are increased; but the precise new substances formed are unknown to us. Nor let any one suppose that the increase of the hydrogen, and of the oxygen of the sap, is the same thing as the addition of a quantity of water. Far from it. The substances into which the sap is converted have been enumerated in the last chapter; almost all of them consist chiefly of carbon, hydrogen, and oxygen, and yet none of them has the smallest resemblance to water. In water, oxygen and hydrogen are already combined together in a certain proportion; and this combination must be broken before these elementary bodies can enter into those triple compounds with carbon, of which a great part of the vegetable products consist. We have not the smallest conception of the manner in which these triple combinations are formed, and as little of the manner in which the bodies which compose vegetable substances are combined together. The combination may, for any thing we know to the contrary, be very complicated, though it consists only of three ingredients; and analogy leads us to suppose, that it actually is very complicated: for in chemistry it may be considered as a truth, to which at present few or no exceptions are known, that bodies are decomposed with a facility inversely as the simplicity of their composition; that is to say, that those bodies which consist of the fewest ingredients are most difficultly decomposed, and that those which are formed of many ingredients are decomposed with the greatest facility.

Neither let any one suppose, that the absorption of carbonic acid gas, during the day, is balanced by the quantity emitted during the night, and that therefore there is no increase of carbon: for Ingenhousz has shewn, that the quantity of oxygen gas emitted during the day is much greater than the carbonic acid gas emitted during the night; and that in favourable circumstances, the quantity of oxygen gas in the air surrounding plants is very much increased, and the carbonic acid gas diminished; so much so, that both Dr Priestley and Dr Ingenhousz found, that air which had been spoiled by a lighted candle, or by animals, was rendered as good as ever by plants. Now we know, that combustion and respiration diminish the oxygen gas, and add carbonic acid gas to air; therefore vegetation, which restores the purity of air altered by these processes, must increase the oxygen, and diminish the carbonic acid gas of that air; consequently the quantity of carbonic acid gas absorbed by plants during the day is greater than the quantity emitted by them during the night, and of course the carbon of the sap is increased in the leaves.

It is true, that when plants are made to vegetate for a number of days in a given quantity of air, its ingredients are not found to be altered. Thus Hassenfratz ascertained, that the air in which young chesnuts vegetated for a number of days together, was not altered in its properties, whether the chesnuts were vegetating in water or in earth *. And Saussure the Younger proved, that pease growing for ten days in water did not alter the surrounding air †. But this is precisely what ought to be the case, and what must take place, provided the conclusions which we have drawn be just. For if plants only emit oxygen gas, by absorbing and decomposing carbonic acid gas, it is evident, that unless carbonic acid gas be present, they can emit no oxygen gas; and whenever they have decomposed all the carbonic acid gas contained in a given quantity of air, we have no longer any reason to look for their emitting any more oxygen gas; and if the quantity of carbonic acid gas emitted during the night be smaller than that absorbed during the day, it is evident, that during the day the plant will constantly decompose all the acid which had been formed during the night. By these processes, the mutual changes of day and night compensate each other; and they are prevented from more than compensating each other by the forced state of the plant. It is probable, that when only part of a plant is made to vegetate in this forced state, some *carbonated sap* (if we may be allowed the expression) is supplied by the rest of the plant; and that therefore the quantity of carbonic acid gas emitted during the night may bear a nearer proportion to that emitted in a state of nature, than that of the absorption of fixed air can possibly do. And probably, even when the whole plant is thus confined, the nightly process goes on for a certain time at the expence of the carbon already in the sap; for Hassenfratz found, that in these cases the quantity of carbon in the plant, after it had vegetated for some time in the dark, was less than it had been when it began to vegetate *. This is the reason that plants growing in the dark, when confined, absorb all the oxygen gas, and emit an equal quantity of carbonic acid gas: and whenever this has happened, they die; because then neither the daily nor nightly processes can go on.

* *Ann. de Chim.* xiii. 25.

† *Ibid.* xxiv. 139.

* *Ann. de Chim.* xiii. 168.

24. Certain changes are also produced on the sap in the leaves by the action of light; and these changes seem to be in some measure independent, or at least different from the absorption and decomposition of carbonic acid gas, in which light, as we have seen, acts an important part.

155
Green colour of plants produced by light.

The green colour of plants is owing entirely to their vegetating in the light; for when they vegetate in the dark they are white; and when exposed to the light, they acquire a green colour in a very short time, in what-

Vegetation.

whatfoever fituation they are placed, even though plunged in water, provided always that oxygen be prefent; for Mr Gough has fhewn, that light without oxygen has not the power of producing the green colour *. In what manner this change is operated, cannot, in the prefent limited ftate of our knowledge, be afcertained. We know too little about the properties of light to be able even to conjecture with any plaufibility. We know indeed, that part of the light is abforbed by green plants; but this will not account for the phenomenon. When dilated, it amounts to no more than this, that plants which have grown in the dark reflect all the rays of light; while thofe which vegetate in the light reflect the green and abforb the others. The very mention of this phenomenon is enough to fhew us, that we have not advanced far enough to be able to explain it.

* Manch. Memoirs, iv. 501.

Etiolated (E) plants want fomething, or poffefs fomething peculiar; and it is on this fomething that the phenomenon depends. But what is this fomething? The fudden appearance of the green colour is rather againft the fuppofition, that it is owing to any fpecific change in the qualities of the fap.

Senebier has obferved, that when plants are made to vegetate in the dark, their etiolation is much diminifhed by mixing a little hydrogen gas with the air that furrounds them *. Ingenhoufz had already remarked, that when a little hydrogen gas is added to the air in which plants vegetate, even in the light, it renders their verdure deeper †: and he feems to think alfo, that he has proved by experiments, that plants abforb hydrogen gas in thefe circumftances ‡. Mr Humbolt has obferved that the poa annua and compreffa, plantago lanceolata, trifolium arvenfe, cheiranthus cheiri, lichen verticillatus, and feveral other plants which grow in the galleries of mines, retain their green colour even in the dark, and that in thefe cafes the air around them contains a quantity of hydrogen gas. Thefe facts are fufficient to fhew that there is fome connection between the green colour of plants and the action of hydrogen gas on them; but what that connection is, it is impoffible at prefent to fay.

* Enc. Method. Phif. Veget. 77.
† Ann. de Chim. iii. 57.
‡ Ibid. 61.

25. By thefe different changes which go on in the leaves, the nature of the fap is altogether changed. It is now converted into what is called the *peculiar juice*, and is fit for being affimilated to the different parts of the plant, and for being employed in the formation of thofe fecretions which are neceffary for the purpofes of the vegetable economy.

156 Leaves the digefting organs of plants.

The leaves, therefore, may be confidered as the digefting organs of plants, and as equivalent in fome meafure to the ftomach and lungs of animals. The leaves confequently are not mere ornaments; they are the moft important parts of the plant. Accordingly we find, that whenever we ftrip a plant of its leaves, we ftrip it entirely of its vegetating powers till new leaves are formed. It is well known, that when the leaves of plants are deftroyed by infects they vegetate no longer, and that their fruit never make any farther progrefs in ripening, but decays and dries up. Even in germination no progrefs is made in the growth of the ftem till the feed leaves appear. As much food indeed is laid up in the cotyledons as advances the plant to a certain ftate, the root is prepared, and made ready to perform its functions; but the fap which it imbibes muft be firft carried to the feed leaves, and digefted there, before it be proper for forming the plumula into a ftem. Accordingly if the feed leaves are cut off, the plant refufes to vegetate.

157 How they are produced.

It will be very natural to afk, If this be true, how come the leaves themfelves to be produced? Even if no anfwer could be given to this queftion, it could not overturn a fingle fact which has been formerly mentioned, nor affect a fingle conclufion as far as it has been fairly deduced from thefe facts. We know that the leaves exift long before they appear; they have been traced even five years back. They are completely formed in the bud, and fairly rolled up for evolution, many months before that fpring in which they expand. We know, too, that if we take a bud, and plant it properly, it vegetates, forms to itfelf a root, and becomes a complete plant. It will not be faid, furely, that in this cafe the bud imbibes nourifhment from the earth; for it has to form a root before it can obtain nourifhment in that manner; and this root cannot be formed without nourifhment. Is not this a demonftration that the bud contains, already laid up in itfelf, a fufficient quantity of nourifhment, not only to develope its own organs, but alfo to form new ones. This we confider as a fufficient anfwer to the objection. During the fummer, the plant lays up a fufficient quantity of nourifhment in each bud, and this nourifhment is afterwards employed in developing the leaves. This is the reafon that the leaves make their appearance, and that they grow during the winter, when the plant is deprived of its organs of digeftion.

Hence we fee why the branch of a vine, if it be introduced into a hothoufe during the winter, puts forth leaves and vegetates with vigour, while every other part of the plant gives no figns of life. Hence alfo the reafon that the inoculation of plants fucceeds (F).

If a tree be deprived of its leaves, new leaves make their appearance, becaufe they are already prepared for that purpofe: but what would be the confequence if a tree were deprived of its leaves and of all its buds for five

(E) Plants of a white colour, from vegetating in the dark, are called *etiolated*, from a French word which fignifies a *ftar*, as if they grew by *ftar light*.

(F) Hence alfo the caufe of another well known phenomenon. The fap flows out of trees very readily in fpring before the leaves appear, but after that the bleeding ceafes altogether. It is evident that there can be fcarcely any circulation of fap before the leaves appear; for as there is no outlet, when the veffels are once full, they can admit no more. It appears, however, from the bleeding, that the roots are capable of imbibing, and the veffels of circulating the fap with vigour. Accordingly, whenever there is an outlet, they perform their functions as ufual, and the tree bleeds; that is, they fend up a quantity of fap to be digefted as ufual: but as there are no digefting organs, it flows out, and the tree receives no injury, becaufe the fap that flows out would not have been imbibed at all, had it not been for the artificial opening. But when the digeftive organs appear, the tree will not bleed; becaufe thefe organs require all the fap, and it is conftantly flowing to them.

Vegetation.

five years back? That plants do not vegetate without leaves, is evident from an experiment of Duhamel. He ſtript the bark off a tree in ringlets ſo as to leave five or ſix rings of it at ſome diſtance from each other, with no bark in the intervals. Some of theſe rings had buds and leaves; theſe increaſed conſiderably in ſize; but one ring which had none of theſe remained for years unaltered.

158 Nature of the peculiar juices.

26. The peculiar juice thus formed in the leaves is carried by veſſels intended for that uſe to all the parts of the plant, in order to be employed for the purpoſes of vegetation;—to increaſe the wood, the bark, the roots; to prepare the ſeeds, lay up nouriſhment for the buds, and to repair the decayed parts of the ſyſtem, or form new ones.

If we had any method of obtaining this peculiar juice in a ſtate of purity, the analyſis of it would throw a great deal of light upon vegetation; but this is ſcarce poſſible, as we cannot extract it without dividing at the ſame time the veſſels which contain the ſap. In many caſes, however, the peculiar juice may be known by its colour; and then its analyſis may be performed with an approach towards accuracy. The experiments made on ſuch juices have proved, as might have been expected, that they differ very conſiderably from each other, and that every plant has a juice peculiar to itſelf. Hence it follows, that the proceſſes which go on in the leaves of plants muſt differ at leaſt in degree, and that we have no right to transfer the concluſions deduced from experiments on one ſpecies of plants to thoſe of another ſpecies. It is even probable, that the proceſſes in different plants are not the ſame in kind; for it is not reaſonable to ſuppoſe, that the phenomena of vegetation in an agaric or a boletus are preciſely the ſame as thoſe which take place in trees and in larger vegetables, on which alone experiments have hitherto been made.

To attempt any general account of the ingredients of the peculiar juice of plants, is at preſent impoſſible. We may conclude, however, from the experiments of Chaptal, that it contains the *vegetable fibre* of wood, either ready formed, or very nearly ſo; juſt as the blood in animals contains a ſubſtance which bears a ſtrong reſemblance to the muſcular fibres.

When oxy-muriatic acid was poured into the peculiar juice of the euphorbia, which in all the ſpecies of that ſingular genus is of a milky colour and conſiſtency, a very copious white precipitate fell down. This powder, when waſhed and dried, had the appearance of fine ſtarch, and was not altered by keeping. It was neither affected by water nor alkalies. Alcohol, aſſiſted by heat, diſſolved two thirds of it; which were again precipitated by water, and had all the properties of reſin. The remaining third part poſſeſſed the properties of the *woody fibre*. Mr Chaptal tried the ſame experiment on the juices of a great number of other plants, and he conſtantly found that oxy-muriatic acid precipitated from them *woody fibre*. The ſeeds of plants exhibited exactly the ſame phenomenon; and a greater quantity of woody fibre was obtained from them than from an equal portion of the juices of plants *. Theſe experiments are ſufficient to ſhew, that the proper juices of plants contain their nouriſhment ready prepared, nearly in the ſtate in which it exiſts in the ſeed for the uſe of the young embryo.

* Ann. de Chim. xxi. 85.

The peculiar juices of plants, then, contain more carbon, hydrogen, and oxygen and leſs water, and probably lime alſo, than the ſap. They are conveyed to every part of the plant; and all the ſubſtances which we find in plants, and even the organs themſelves, by which they perform their functions, are formed from them. But the thickeſt veil covers the whole of theſe proceſſes; and ſo far have philoſophers hitherto been from removing this veil, that they have not even been able to approach it. All theſe operations, indeed, are evidently chemical decompoſitions and combinations; but we neither know what theſe decompoſitions and combinations are, nor the inſtruments in which they take place, nor the agents by which they are regulated.

159 Its uſes.

160 Plants decay and die.

27. Such, as far as we are acquainted with them, are the changes produced by vegetation. But plants do not continue to vegetate for ever; ſooner or later they decay, and wither, and rot, and are totally decompoſed. This change indeed does not happen to all plants at the end of the ſame time. Some live only for a ſingle ſeaſon, or even for a ſhorter period; others live two ſeaſons, others three, others a hundred or more; and there are ſome plants which continue to vegetate for a thouſand years. But ſooner or later they all ceaſe to live; and then thoſe very chemical and mechanical powers which had promoted vegetation combine to deſtroy the remains of the plant. Now, What is the cauſe of this change? Why do plants die?

This queſtion can only be anſwered by examining with ſome care what it is which conſtitutes the *life* of plants; for it is evident, that if we can diſcover what that is which conſtitutes the life of a plant, it cannot be difficult to diſcover what conſtitutes its death.

161 Phenomena of vegetable life.

Now the phenomena of vegetable life are in general *vegetation*. As long as a plant continues to vegetate, we ſay that it lives; when it ceaſes to vegetate, we conclude that it is dead.

The life of vegetables, however, is not ſo intimately connected with the phenomena of vegetation that they cannot be ſeparated. Many ſeeds may be kept for years without giving any ſymptom of vegetation; yet if they vegetate when put into the earth, we ſay that they poſſeſs life: and if we would ſpeak accurately, we muſt ſay alſo, that they poſſeſſed life even before they were put into the earth; for it would be abſurd to ſuppoſe that the ſeed *obtained* life merely by being put into the earth. In like manner, many plants decay, and give no ſymptoms of vegetation during winter; yet if they vegetate when the mild temperature of ſpring affects them, we conſider them as having lived all winter. The life of plants, then, and the phenomena of vegetation, are not preciſely the ſame thing; for the one may be ſeparated from the other, and we can even ſuppoſe the one to exiſt without the other. Nay, what is more, we can, in many caſes, *decide*, without heſitation, that a vegetable is not dead, even when no vegetation appears; and the proof which we have for its life is, that it *remains unaltered*; for we know that when a vegetable is dead, it ſoon changes its appearance, and falls into decay.

Thus it appears that the *life* of a vegetable conſiſts in two things. 1. In remaining unaltered, when circumſtances are unfavourable to vegetation; 2 In exhibiting

Vegetation. hibiting the phenomena of vegetation when circumftances are favourable. When neither of thefe two things happens, we fay that a vegetable is dead.

The phenomena of vegetation have been enumerated above. They confift in the formation or expanfion of the organs of the plant, in the taking in of nourifhment, in carrying it to the leaves, in digefting it, in diftributing it through the plant, in augmenting the bulk of the plant, in repairing decayed parts, in forming new organs when they are neceffary, in producing feeds capable of being converted into plants fimilar to the parent. The *caufe* of thefe phenomena, whatever it may be, is the *caufe* alfo of *vegetable life*.

All the fubftances which have been enumerated in the firft part of the article CHEMISTRY, *Suppl.* together with their compounds and component parts, poffefs certain qualities in common: in confequence of which, a term has been invented which includes them all. This term is *matter*. Now thefe common qualities may all ultimately be refolved into certain attractions and repulfions which thefe fubftances exert. Thefe qualities may be faid, without any impropriety, to be *effential to matter*; becaufe every body to which we give the name of *matter* poffeffes them; and if any body were to be deprived of thefe qualities, it could no longer be included under the denomination *matter*. In fhort, the word *matter* comprehends under it certain qualities: every fubftance which poffeffes thefe qualities is called *matter*; and no other fubftance except thefe can receive the name of *matter* without altering the meaning of the word.

162 Not reducible to the laws of matter;

The attractions and repulfions of matter have been examined with care; and the changes which they produce have been afcertained with confiderable accuracy. They have even been reduced to general principles under the name of *mechanical and chemical laws*. Whenever any change is obferved, if that change be a cafe of a mechanical or chemical law, we fay that the agent is *matter*; but if the change cannot be reduced under thefe laws, or if it be incompatible with thefe laws, we muft fay, unlefs we would pervert the meaning of words altogether, that the agent is not *matter*.

Now it cannot be difputed that feveral of the phenomena of life in vegetables are incompatible with the laws of mechanics and chemiftry. The motion of the fap, for inftance, muft be produced by the contraction of the veffels; and the contraction of veffels, on the application of ftimuli, is incompatible with the laws of chemiftry, becaufe no decompofition takes place; and of mechanics, becaufe a much greater force is generated than the generating body itfelf poffeffed. The evolution of the organs of vegetables, the reparation of decayed organs, the formation of new ones to fupply the place of the old, the production of feeds capable of producing new plants, the conftant fimilarity of individuals of the fame fpecies—thefe, and many other well known phenomena, cannot be reduced under mechanical and chemical laws. The caufe of life, then, in plants, is a *fubftance* (for we can form no conception of an agent which is not a fubftance) which does not act according to the laws of mechanics and chemiftry, and which confequently is *not matter*. We fhall therefore, till a better name be chofen, denominate it the *vegetative principle* (G).

163 Confequently owing to an immaterial caufe.

164 Nature of the vegetative principle.

The nature of the *vegetative principle* can only be deduced from the phenomena of vegetation. It evidently follows a fixed plan, and its actions are directed to promote the good of the plant. It has a power over matter, and is capable of directing its attractions and repulfions, in fuch a manner as to render them the inftruments of the formation, and improvement, and prefervation of the plant. It is capable alfo of generating fubftances endowed with powers fimilar to itfelf. The plan according to which it acts, difplays the moft confummate wifdom and forefight, and a knowledge of the properties of matter infinitely beyond what man can boaft.

165 Whether endowed with confcioufnefs.

Metaphyficians have thought proper to divide all fubftances into two claffes, *matter* and *mind*. If we follow this divifion, the vegetative principle, as it is not *material*, muft undoubtedly be ranked under *mind*. But if *confcioufnefs* and *intelligence* be confidered as effential to mind, which is the cafe according to their definition, we cannot give the vegetative principle the name of *mind*, becaufe it has not been proved that it poffeffes confcioufnefs and intelligence. It acts indeed according to a fixed plan, which difplays the higheft degree of intelligence; but this plan may belong, not to the vegetative principle itfelf, but to the Being who formed that principle. We can conceive it to have been endowed by the Author of Nature with peculiar powers, which it muft always exert according to certain fixed laws; and the phenomena of vegetation *may be* the refult of this mode of acting. This, as far as we can fee, is not impoffible. It muft be fhewn to be impoffible by every perfon who wifhes to prove that plants poffefs confcioufnefs and intelligence; for the proofs of this confcioufnefs can only be deduced from the defign which the actions of plants manifeft. Thofe philofophers who have afcribed confcioufnefs and intelligence to plants, have founded their belief principally on certain actions which plants perform on the application of ftimuli. But thefe actions prove nothing more than what cannot be denied, that there exifts a vegetative principle, which is not material, and which has certain properties in common with the living principles of animals; but whether or not this vegetative principle poffeffes confcioufnefs and intelligence, is a very different queftion, and muft be decided by very different proofs. We do not fay that the heart of an animal is confcious, becaufe it continues to beat on the application of proper ftimuli for fome time after it has been feparated from the reft of the body.

166 Death of plants.

The death of plants, if we can judge from the phenomena, is owing, not to the vegetative principle leaving them, but to the organs becoming at laft altogether unfit for performing their functions, and incapable of being repaired by any of the powers which that principle poffeffes. The changes which vegetable fubftances undergo after death come now to be examined. They fhall form the fubject of the enfuing chapter.

CHAP.

(G) Phyfiologifts have ufually given it the name of *living principle*. We would have adopted that name, if it had not been too general for our purpofe.

Bread.

CHAP. III. OF THE DECOMPOSITION OF VEGETABLE SUBSTANCES.

NOT only entire plants undergo decompofition after death, but certain vegetable fubftances alfo, whenever they are mixed together, and placed in proper circum-
167 Vegetable decompofitions, ftances, mutually decompofe each other, and new compound fubftances are produced. Thefe mutual decompofitions, indeed, are naturally to be expected: for as all vegetable fubftances are compofed of feveral ingredients, differing in the ftrength of their affinity for each other, it is to be fuppofed that, when two fuch fubftances are mixed together, the divellent affinities will, in many cafes, prove ftronger than the quiefcent; and therefore decompofition, and the formation of new compounds, muft take place: juft as happens when the acetite of lead and fulphat of potafs are mixed together.

Thefe mutual decompofitions of vegetable fubftances are by no means fo eafily traced, or fo readily explained, as the mutual decompofitions of neutral falts; partly on account of the number of fubftances, whofe affinities for each other are brought into action, and partly becaufe we are ignorant of the manner in which the ingredients of vegetable fubftances are mutually combined.

168 Called FERMENTATION. Chemifts have agreed to give thefe mutual decompofitions which take place in vegetable fubftances the name of *fermentation*; a word firft introduced into chemiftry by Van Helmont *; and the new fubftances produced they have called the *products* of fermentation. All the phenomena of fermentation lay for many years concealed in the completeft darknefs, and no chemift was bold enough to hazard even an attempt to explain them. They were employed, however, and without hefitation too, in the explanation of other phenomena; as if giving to one procefs, the name of another of which we are equally ignorant, could, in reality, add any thing to our knowledge. The darknefs which enveloped thefe phenomena has lately begun to difperfe; but they are ftill furrounded with a very thick mift; and we muft be much better acquainted with the compofition of vegetable fubftances, and the mutual affinities of their ingredients, than we are at prefent, before we can explain them in a fatisfactory manner.

* *Stahl, Fundament. Chim.* i. 124.

169 Divifion of them. The vegetable fermentations or decompofitions may be arranged under five heads; namely, that which produces *bread*, that which produces *wine*, that which produces *beer*, that which produces *acetous acid* or *vinegar*, and the *putrefactive* fermentation, or that which produces the fpontaneous decompofition of decayed vegetables. Thefe fhall be the fubject of the five following fections. In order to avoid long titles, we fhall give to the firft three fections the name of the new fubftances produced by the fermentation.

SECT. I. *Of BREAD.*

170 Difcovery of bread. SIMPLE as the manufacture of bread may appear to us who have been always accuftomed to confider it as a common procefs, its difcovery was probably the work of ages, and the refult of the united efforts of men, whofe fagacity, had they lived in a more fortunate period of fociety, would have rendered them the rivals of Ariftotle or of Newton.

The method of making bread fimilar to ours was known in the Eaft at a very early period; but neither the precife time of the difcovery, nor the name of the perfon who publifhed it to the world, has been preferved. We are certain that the Jews were acquainted with it in the time of Mofes; for in Exodus * we find a prohibition to ufe leavened bread during the celebration of the paffover. It does not appear, however, to have been known to Abraham; for we hear in his hiftory of cakes frequently, but nothing of leaven. Egypt, both from the nature of the foil and the early period at which it was civilized, bids faireft for the difcovery of making bread. It can fcarcely be doubted that the Jews learned the art from the Egyptians. The Greeks affure us that they were taught the art of making bread by the god Pan. We learn from Homer that it was known during the Trojan war †. The Romans were ignorant of the method of making bread till the year 580, after the building of Rome, or 200 years before the commencement of the Chriftian era ‡. Since that period the art has never been unknown in the fouth of Europe; but it made its way to the north very flowly, and even at prefent in many northern countries fermented bread is but very feldom ufed.

* Ch. xii. v. 15.

† *Iliad*, ix. 216.

‡ *Plin.* l. 18. cap. 11.

171 Subftances which make bread. The only fubftance well adapted for making bread, we mean *loaf bread*, is wheat flour, which is compofed of four ingredients; namely, gluten, ftarch, albumen, and a *fweet mucous matter*, which poffeffes nearly the properties of fugar, and which is probably a mixture of fugar and mucilage. It is to the gluten that wheat flour owes its fuperiority to every other as the bafis of bread. Indeed there are only two other fubftances at prefent known of which good loaf bread can be made; thefe are *rye* and *potatoes*. The rye loaf is by no means fo well raifed as the wheat loaf; and potatoes will not make bread at all without particular management. Potatoes, previoufly boiled and reduced to a very fine tough pafte by a rolling pin, muft be mixed with an equal weight of potatoe ftarch. This mixture, baked in the ufual way, makes a very white, well raifed, pleafant bread. We are indebted for the procefs to Mr Permentier. Barley-meal perhaps might be fubftituted for ftarch.

172 Baking of bread. The baking of bread confifts in mixing wheat flour with water, and forming it into a pafte. The average proportion of thefe is two parts of water to three of flour. But this proportion varies confiderably, according to the age and the quality of the flour. In general, the older and the better the flour is, the greater is the quantity of water required. If the pafte, after being thus formed, be allowed to remain for fome time, its ingredients gradually act upon each other, and the pafte acquires new properties. It gets a difagreeable four tafte, and a quantity of gas (probably carbonic acid gas) is evolved. In fhort, the pafte ferments (H). Thefe changes do not take place without water; that liquid, therefore, is a neceffary agent. Poffibly it is decompofed by the action of the ftarch upon it; for when ftarch is diluted with water, it gradually becomes four. The gluten, too, is altered, either by the action of the water on it, or of the ftarch; for if we examine the pafte after

(H) It was from this procefs that Van Helmont transferred the word *fermentation* into chemiftry.

Bread. after it has undergone fermentation, the gluten is no longer to be found. If paste, after standing for a sufficient time to ferment, be baked in the usual way, it forms a loaf full of eyes like our bread, but of a taste so sour and unpleasant that it cannot be eaten. If a small quantity of this old paste, or *leaven* as it is called, be mixed with new made paste, the whole begins to ferment in a short time; a quantity of gas is evolved; but the glutinous part of the flour renders the paste so tough, that the gas cannot escape; it therefore causes the paste to swell in every direction: and if it be now baked into loaves, the immense number of air bubbles imprisoned in every part renders the bread quite full of eyes, and very light. If the precise quantity of leaven necessary to produce the fermentation, and no more, has been used, the bread is sufficiently light, and has no unpleasant taste; but if too much leaven be employed, the bread has a bad taste; if too little, the fermentation does not come on, and the bread is too compact and heavy. To make good bread with leaven, therefore, is very difficult.

The ancient Gauls had another method of fermenting bread. They formed their paste in the usual way; and instead of leaven, mixed with it a little of the *barm* which collects on the surface of fermenting beer *. This mixture produced as complete and as speedy a fermentation as leaven; and it had the great advantage of not being apt to spoil the taste of the bread. About the end of the 17th century, the bakers in Paris began to introduce this practice into their processes. The practice was discovered, and exclaimed against; the faculty of medicine, in 1688, declared it prejudicial to health; and it was not till after a long time that the bakers succeeded in convincing the public that bread baked with *barm* is superior to bread baked with leaven. In this country the bread has for these many years been fermented with barm.

* Plin. xviii. 7.

173 Barm. What is this *barm* which produces these effects? The question is curious and important; but we are not able to answer it completely. Mr Henry of Manchester has concluded, from a number of very interesting experiments, that the only useful part of barm is carbonic acid gas, and that this gas therefore is the real fermenter of paste †.

† Manch. Mem. ii. 262.

That the barm of beer, in its usual state, contains carbonic acid gas, cannot be doubted; and that carbonic acid gas acts as a ferment, the experiments of Mr Henry prove decisively. But that the only active part of barm is carbonic acid gas, and nothing but carbonic gas, is extremely doubtful, or rather we are certain that it is not true. It has been customary with the bakers of Paris to bring their barm from Flanders and Picardy in a state of dryness. When skimmed off the beer, it is put into sacks, and the moisture allowed to drop out; then these sacks are subjected to a strong pressure, and when the barm is dry it is made up into balls †. Now, in this state, it is not to be supposed that bubbles of carbonic acid can remain entangled in the barm; they must have been squeezed out by the press, and by the subsequent formation of the barm into balls: yet this barm, when moistened with water, ferments the bread as well as new barm.

† Enc. Meth. art. i. 249.

After the bread has fermented, and is properly raised, it is put into the oven previously heated, and allowed to remain till it be baked. The mean heat of an oven, as ascertained by Mr Tillet, is 448° *. The bakers do not use a thermometer; but they judge that the oven is arrived at the proper heat when flour thrown on the floor of it becomes black very soon without taking fire. We see, from Tillet's experiment, that this happens at the heat of 448°. 174 Heat of the oven.

* Enc. Meth. art. i. 275.

When the bread is taken out of the oven, it is found to be lighter than when put in; as might naturally have been expected, from the evaporation of moisture, which must have taken place at that temperature. Mr Tillet, and the other commissioners who were appointed to examine this subject in consequence of a petition from the bakers of Paris, found that a loaf, which weighed before it was put into the oven 4.625 lbs. after being taken out baked, weighed, at an average, only 3.813 lbs. or 0.812 lb. less than the paste. Consequently 100 parts of paste, lose, at an average, 17.34 parts, or somewhat more than $\frac{1}{5}$th by baking *. They found, however, that this loss of weight was by no means uniform, even with respect to those loaves which were in the oven at the same time, of the same form, and in the same place, and which were put in and taken out at the same instant. The greatest difference in these circumstances amounted to .2889, or 7.5 parts in the hundred, which is about $\frac{1}{13}$th of the whole. This difference is very considerable, and it is not easy to say to what it is owing. It is evident, that if the paste has not all the same degree of moisture, and if the barm be not accurately mixed through the whole, if the fermentation of the whole be not precisely the same, that these differences must take place. Now it is needless to observe how difficult it is to perform all this completely. The French commissioners found, as might indeed have been expected, that, other things being equal, the loss of weight sustained is proportional to the extent of surface of the loaf, and to the length of time that it remains in the oven; that is to say, the smaller the extent of the external surface, or, which is the same thing, the nearer the loaf approaches to a globular figure, the smaller is the loss of weight which it sustains; and the longer it continues in the oven, the greater is the loss of weight which it sustains. Thus a loaf which weighed exactly 4 lbs. when newly taken out of the oven, being replaced as soon as weighed, lost, in ten minutes, .125 lb. of its weight, and in ten minutes more it again lost .0625 lb. †. 175 Loss of weight sustained in it.

* Ibid. 275.

† Ibid. p. 270.

Loaves are heaviest when just taken out of the oven; they gradually lose part of their weight, at least if not kept in a damp place, or wrapt round with a wet cloth (K). Thus Mr Tillet found that a loaf of 4 lbs. after being kept for a week, wanted .3125, or nearly $\frac{1}{13}$th of its original weight ‡.

‡ Ibid.

When bread is newly taken out of the oven, it has a peculiar, and rather pleasant smell, which it loses by keeping; as it does also the peculiar taste by which new bread is distinguished. This shews us, that the bread undergoes chemical changes; but what these changes are, or what the peculiar substance is to which the odour of bread is owing, is not known. 176 Properties of bread.

Bread

(K) This is an excellent method of preserving bread fresh, and free from mould, for a long time.

Wine. Bread differs very completely from the flour of which it is made, for none of the ingredients of the flour can now be difcovered in it. The only chemift who has attempted an analyfis of bread is Mr Geoffroy. He found that 100 parts of bread contained the following ingredients:

24.735 water.
32.030 gelatinous matter, extracted by boiling water.
39.843 refiduum infoluble in water.

96.608
3.392 lofs.

100.

But this analyfis, which was publifhed in the Memoirs of the French Academy for the year 1732, was made at a time when the infant ftate of the fcience of chemiftry did not admit of any thing like accuracy.

SECT. II. *Of Wine.*

177 Fruits affording wine. THERE is a confiderable number of ripe fruits from which a fweet liquor may be expreffed, having at the fame time a certain degree of acidity. Of fuch fruits we have in this country the apple, the cherry, the goofeberry, the currant, &c. but by far the moft valuable of thefe fruits is the *grape*, which grows luxuriantly in the fouthern parts of Europe. From grapes, fully ripe, may be expreffed a liquid of a fweet tafte, to which the name of *muft* has been given. This liquid is compofed almoft entirely of five ingredients; namely, *water*, *fugar*, *jelly*, *mucilage*, and *tartarous* acid partly faturated with potafs. The quantity of fugar which grapes fully ripe contain is very confiderable; it may be obtained in cryftals by evaporating muft to the confiftence of fyrup, feparating the tartar which precipitates during the evaporation, and then fetting the muft afide for fome months. The cryftals of fugar are gradually formed.

178 Undergo the vinous fermentation; When muft is put into the temperature of about 70°, the different ingredients begin to act upon each other, and what is called *vinous fermentation* commences. The phenomena of this fermentation are an inteftine motion in the liquid, its becoming thick and muddy, a temperature equal to 72.5°, and an evolution of carbonic acid gas. In a few days the fermentation ceafes, the thick part fubfides to the bottom, the liquid becomes clear, it has loft much of its faccharine tafte, and affumed a new one, its fpecific gravity is diminifhed; and in fhort, it has become the liquid well known under the name of *wine*.

Now what is the caufe of this fermentation; what are the fubftances which mutually decompofe each other; and what is the nature of the new fubftance formed?

Thefe changes are produced altogether by the mutual action of the fubftances contained in muft; for they take place equally well, and wine is formed equally well in clofe veffels as in the open air §.

If the *muft* be evaporated to the confiftency of a thick fyrup, or to a *rob*, as the elder chemifts termed

179 For which water, it, the fermentation will not commence, though the proper temperature, and every thing elfe neceffary to produce fermentation, be prefent ‖. But if this fyrup be again diluted with water, and placed in favourable circumftances, it will ferment. Therefore the prefence of *water* is abfolutely neceffary for the exiftence of vinous fermentation.

180 Sugar, If the juice of thofe fruits which contain but little fugar, as currants, be put into a favourable fituation, fermentation indeed takes place, but fo flowly, that the product is not *wine*, but *vinegar*: but if a fufficient quantity of fugar be added to thefe very juices, wine is readily produced. No fubftance whatever can be made to undergo vinous fermentation, and to produce wine, unlefs fugar be prefent. *Sugar* therefore is abfolutely neceffary for the exiftence of vinous fermentation; and we are certain that it is decompofed during the procefs, for no fugar can be obtained from properly fermented wine.

181 An acid, All thofe juices of fruits which undergo the vinous fermentation, either with or without the addition of fugar, contain an acid. We have feen already in the firft chapter that the vegetable acids are obtained chiefly from fruits. The apple, for inftance, contains malic acid; the lemon, citric acid; the grape, tartarous acid. The Marquis de Bullion has afcertained, that *muft* will not ferment if all the tartarous acid which it contains be feparated from it *. We may conclude from this, that the prefence of a vegetable acid is abfolutely neceffary for the commencement of the vinous fermentation. This renders it probable that the effential part of barm is a vegetable acid, or fomething equivalent; for if fugar be diffolved in four times its weight of water, mixed with the yeaft of beer, and placed in a proper temperature, it undergoes the vinous fermentation †.

182 And jelly are neceffary. All the juices of fruits which undergo the vinous fermentation contain a quantity of jelly, or mucilage, or of both. Thefe two fubftances refemble each other in fo many particulars, and it is fo difficult to feparate them, that we fhall fuppofe they have the fame effect in the mixture. The prefence of thefe fubftances renders it probable that they alfo are neceffary for the vinous fermentation. Perhaps they act chiefly by their tendency to become acid.

Thus we fee, that for the production of wine a certain temperature, a certain portion of water, fugar, a vegetable acid, and, in all probability, jelly alfo, is neceffary. Mr Lavoifier found that fugar would not ferment unlefs diffolved in at leaft four times its weight of water. This feems to indicate that the particles of fugar muft be removed to a certain diftance from each other before the other ingredients can decompofe them. The evolution and feparation of carbonic acid gas in fuch quantity, fhews us that the proportion of the carbon and the oxygen of the fugar is diminifhed. It is not certain that the mucilage of the wine is decompofed fo completely as the fugar; for it has been obferved, that when the muft abounds in mucilage, the wine is apt to become four.

183 Decompofition of wine. When wine is diftilled by means of a low heat, there comes over a quantity of *alcohol*, and the remainder is a folution of acetous acid. From this fact, it has been concluded that wine is compofed of acetous acid and alcohol. But that the diftillation occafions a chemical change in the ingredients of wine is evident from this, that if we again mix the alcohol and acetous acid, we do not reproduce the wine.

Fourcroy has attempted to fhew that alcohol exifted ready formed; but his proofs are not conclufive. Fabroni

§ *Fabroni*, *Ann. de Chim.* xxxi. 302.

‖ *Stahl*, i.

* *Chaptal.*

† *Bergman.*

Beer.

roni has ſhewn, that alcohol cannot be obtained from new made wine by any other method than diſtillation. When wine is ſatured with very dry carbonat of potaſs, no alcohol makes its appearance on the ſurface of the mixture, yet a very ſmall quantity of alcohol, artificially mixed with wine, may be detected by this method. It is certain, however, that alcohol exiſts ready formed in old wine.

Sect. III. *Of Beer.*

The method of making beer was known in the moſt remote ages; we are ignorant to whom the world is indebted for the diſcovery of it. Beer is uſually made from *barley*.

184 Method of making malt,

The barley is ſteeped in water for about ſixty hours, in order to ſaturate it with that liquid. It ought then to be removed as ſpeedily as poſſible, otherwiſe the water diſſolves, and carries off the moſt valuable part of the grain. This barley is then to be laid in a heap for twenty-four hours; heat is evolved, oxygen gas abſorbed, carbonic acid gas emitted, and germination commences with the ſhooting forth of the radicle. It is then ſpread upon a cool floor, dried ſlowly, and is afterwards known by the name of *malt* *.

* *Collier, Manch. Mem.* v. 185.

Wort,

Malt, previouſly ground to a courſe powder, is to be infuſed in a ſufficient quantity of pure water, of the temperature of 160°, for an hour. The infuſion is then to be drawn off, and more water may be added, at a higher temperature, till all the ſoluble part of the malt is extracted. This infuſion is known by the name of *wort*. It has a ſweet taſte, and contains a quantity of ſaccharine, and doubtleſs alſo of gelatinous matter.

186 And beer.

When *wort* is placed in the temperature of about 60°, fermentation gradually takes place in it, and the very ſame phenomena appear which diſtinguiſh the production of wine. The fermentation of wort, then, is nothing but a particular caſe of the vinous fermentation. But wort does not ferment ſo well, nor ſo ſoon, nor does it produce nearly ſo great a quantity of good fermented liquor, as when *yeaſt* is added to it. The reaſon of which is, probably, that the fermentation does not commence till an acid is generated in the wort, and before that happens part of the ſaccharine contents are decompoſed; whereas the yeaſt adds an acid, or, at leaſt, ſomething equivalent to it, at once.

Wort ferments in cloſe veſſels, as Mr Collier aſcertained by experiment, equally well as in the open air. Therefore the decompoſition is produced entirely by the ſubſtances contained in the wort, without the addition of any thing from the air. The quantity of beer produced in cloſe veſſels is much greater than when the proceſs takes place in the open air. The reaſon of which is, that in the open air the beer gradually evaporates during the fermentation. Thus Mr Collier found that 11 quarts, $3\frac{1}{2}$ oz. fermented in open veſſels, loſt, in 12 days, 40 oz.; whereas an equal weight, fermented in cloſe veſſels, loſt only 8 oz. in the ſame time. Yet the quality of the *beer* was the ſame in each; for equal quantities of both, when diſtilled, yielded preciſely the ſame portion of alcohol †.

† *Ibid*, p. 160.

Acetous Fermentation, Putrefaction.

During the fermentation, a quantity of carbonic acid gas is conſtantly diſengaged, not in a ſtate of purity, but containing, combined with it, a portion of the wort; and if this gas be made to paſs through water, it will depoſite wort, which may be fermented in the uſual manner *.

When beer is diſtilled, alcohol is obtained, and the reſiduum is an acid liquor †. The theory of beer is ſo obviouſly the ſame with that of wine that it requires no additional explanation.

* *Collier, Manch. Mem.*

† *Henry, Mem.* ii. 257.

Sect. IV. *Of the Acetous Fermentation.*

187 Subſtances which undergo the acetous fermentation.

If wine or beer be kept at a temperature between 70° and 90°, it gradually loſes its properties, and is converted into *acetous acid*.

During this change, a quantity of oxygen gas is abſorbed, and the whole of the ſpirituous part of the wine or beer diſappears. Conſequently its ingredients naturally decompoſed each other.

Neither pure alcohol, nor alcohol diluted with water, are capable of undergoing this change, neither do they abſorb any oxygen. This abſorption, then, is made by the mucilaginous matter which always exiſts in theſe liquids. No acetous acid is ever produced, unleſs ſome acid be preſent in the liquid. We may conclude, then, that the mucilage acquires the properties of an acid before it begins to act upon the ſpirituous part of the beer or the wine.

As the acetous acid has been already treated of in the article Chemistry, *Suppl.* it is unneceſſary to dwell any longer on this ſubject here.

Sect. V. *Of Putrefaction.*

188 Nature of putrefaction.

All vegetable ſubſtances, both complete plants and their component parts ſeparately, when left entirely to themſelves, are gradually decompoſed and deſtroyed, provided moiſture be preſent, and the temperature be not much under 45°, nor too high to evaporate ſuddenly all the moiſture, This decompoſition has obtained the name of *putrefaction*.

It proceeds with moſt rapidity in the open air; but the contact of air is not abſolutely neceſſary. Water is, in all caſes, eſſential to the proceſs, and therefore is moſt probably decompoſed.

Putrefaction is conſtantly attended with a fetid odour, owing to the emiſſion of certain gaſeous matters, which differ according to the putrefying ſubſtance. Some vegetable ſubſtances, as gluten, and cruciform plants, emit ammonia; others, as onions, ſeem to emit phoſphorated hydrogen gas. Carbonic acid gas, and hydrogen gas, impregnated with unknown vegetable matters, are almoſt conſtantly emitted in abundance. When the whole proceſs is finiſhed, ſcarcely any thing remains but the earths, the ſalts, and the metals, which formed a conſtituent part of the vegetable. But our chemical knowledge of vegetable compounds is by far too limited to enable us to follow this very complicated proceſs with any chance of ſucceſs.

PART

Part II. Of Animal SUBSTANCES.

gredients animals, Fibrina. WHEN we compare animals and vegetables together, each in their moft perfect ftate, nothing can be eafier than to diftinguifh them. The plant is
189 confined to a particular fpot, and exhibits no marks of
laffes of confcioufnefs or intelligence; the animal, on the con-
imals and trary, can remove at pleafure from one place to another,
getables. is poffeffed of confcioufnefs, and a high degree of intelligence. But on approaching the contiguous extremities of the animal and vegetable kingdom, thefe ftriking differences gradually difappear, the objects acquire a greater degree of refemblance, and at laft approach each other fo nearly, that it is fcarcely poffible to decide whether fome of thofe fituated on the very boundary belong to the animal or vegetable kingdom.

190 ifficulty diftinguifh- To draw a line of diftinction, then, between animals and vegetables, would be a very difficult tafk; but it is not neceffary for us, in this place at leaft, to attempt it; for almoft the only animals whofe bodies have been hitherto examined with any degree of chemical accuracy, belong to the moft perfect claffes, and confequently are in no danger of being confounded with plants. Indeed the greater number of facts which we have to relate, apply only to the human body, and to thofe of a few domeftic animals. The tafk of analyfing all animal bodies is immenfe, and muft be the work of ages of indefatigable induftry.

191 ivifion of is Part. We fhall divide this Part of the article into four chapters. In the firft chapter, we fhall give an account of the different ingredients hitherto found in animals, fuch of them at leaft as have been examined with any degree of accuracy: in the fecond, we fhall treat of the different members of which animal bodies are compofed; which muft confift each of various combinations of the ingredients defcribed in the firft chapter: in the third, we fhall treat of thofe animal functions which may be elucidated by chemiftry: and, in the fourth, of the changes which animal bodies undergo after death.

Chap. I. Of the Ingredients of Animals.

The fubftances which have been hitherto detected in the animal kingdom, and of which the different parts of animals, as far as thefe parts have been analyfed, are found to be compofed, may be arranged under the following heads:

1. Fibrina,	8. Sulphur,
2. Albumen,	9. Oils,
3. Gelatine,	10. Acids,
4. Mucilage,	11. Alkalies,
5. Bafis of bile,	12. Earths,
6. Urea,	13. Metals.
7. Sugar,	

Thefe fhall form the fubject of the following fections:

Sect. I. *Of Fibrina.*

If a quantity of blood, newly drawn from an animal, be allowed to remain at reft for fome time, a thick red clot gradually forms in it, and fubfides. Separate this clot from the reft of the blood, wafh it repeatedly in water till it ceafes to give out any colour or tafte to the liquid; the fubftance which remains after this process is denominated *fibrina*. It has been long known to phyficians under the name of the *fibrous part of the blood*, but has not till lately been accurately defcribed. Albumen. 192 Fibrina how obtained.

193 Its properties. Fibrina is of a white colour, has no tafte, and is infoluble in water and in alcohol. It is foft and ductile, has a confiderable degree of elafticity, and refembles very much the gluten of vegetables.

Pure fixed alkalies do not act upon it, unlefs they be very much concentrated, and then they decompofe it. All the acids combine with it readily, and diffolve it. Water and alkalies feparate it again; but it has loft entirely its former properties. With muriatic acid it forms a green coloured jelly.

When nitric acid is poured upon fibrina, azotic gas is difengaged, as Berthollet firft difcovered. The quantity of this gas is greater than can be obtained from the fame quantity of other animal fubftances by the fame procefs *. After this, pruffic acid and carbonic acid gas are exhaled. By the affiftance of heat the fibrina is diffolved; much nitrous gas is difengaged; the liquid, when concentrated, yields oxalic and malic acids; and white flakes are depofited, confifting of an oily fubftance, and of phofpat of lime †.

When fibrina is diftilled, it yields a very large quantity of ammonia ‡.

Thefe properties are fufficient to fhew us that this fubftance is compofed of azot, hydrogen, and carbon; but neither the precife proportion of thefe ingredients, nor the manner of their combination, are at prefent known.

* Fourcroy, *Ann. de Chim.* i. 41.

† Fourcroy.

‡ Fourcroy, *Ann. de Chim.* i. 43.

Sect. II. *Of Albumen.*

194 Albumen contained in Eggs. The eggs of fowls contain two very different fubftances: a yellow oily-like matter, called the *yolk*; and a colourlefs gloffy vifcid liquid, diftinguifhed by the name of *white*. This laft is the fubftance which chemifts have agreed to denominate *albumen* (L). The white of an egg, however, is not pure albumen. It contains, mixed with it, fome carbonat of foda, and fome fulphur; but the quantity of thefe fubftances is fo fmall that they do not much influence its properties. We fhall therefore confider it as *albumen*.

195 Coagulated by heat. On the application of a heat of 165° § it *coagulates*, as is well known, into a white folid mafs; the confiftency of which, when other things are equal, depends, in fome meafure, on the time during which the heat was applied. The coagulated mafs has precifely the fame weight that it had while fluid.

§ Cullen.

The tafte of coagulated albumen is quite different from that of liquid albumen: its appearance, too, and its

(L) This is merely the Latin term for the white of an egg. It was firft introduced into chemiftry by the phyfiologifts.

Albumen.

its properties, are entirely changed; for it is no longer soluble, as before, either in hot or in cold water.

196 Phenomena of this coagulation.

The coagulation of albumen takes place even though air be completely excluded; and even when air is present there is no absorption of it, nor does albumen in coagulating change its volume *. Acids have the property of coagulating albumen, as Scheele ascertained †. Alcohol also produces, in some measure, the same effect. *Heat*, then, *acids* and *alcohol*, are the agents which may be employed to coagulate albumen.

* Carradori, Ann de Chim xxix 98.

† Scheele, ii 58.

It is remarkable, that if albumen be diluted with a sufficient quantity of water, it can no longer be coagulated by any of those agents. Scheele mixed the white of an egg with ten times its weight of water, and then, though he even *boiled* the liquid, no coagulum appeared. Acids indeed, and alcohol, even then coagulated it; but they also lose their power, if the albumen be diluted with a much greater quantity of water, as has been ascertained by many experiments. Now we know, that when water is poured into albumen, not only a mechanical mixture takes place, but a chemical combination; for the albumen is equally distributed through every part of the liquid. Consequently its integrant particles must be farther separated from each other, and their distance must increase with the quantity of water with which they are diluted. We see, therefore, that albumen ceases to coagulate whenever its particles are separated from each other beyond a certain distance. That no other change is produced, appears evident from this circumstance, that whenever the watery solution of albumen is sufficiently concentrated by evaporation, coagulation takes place, upon the application of the proper agents, precisely as formerly.

It does not appear that the distance of the particles of albumen is changed by coagulation; for coagulated albumen occupies precisely the same sensible space as liquid albumen *.

* Carradori.

197 Enquiry into its cause.

Thus two things seem certain respecting the coagulation of albumen: 1. That its particles must not be beyond a certain distance; 2. That the coagulation does not produce any sensible change in their distance. To what, then, is the coagulation of albumen owing? We can conceive no change to take place from a state of liquidity to that of solidity, without some change in the figure of the particles of the body which has undergone that change: for if the figure and the distance of the particles of bodies continue the same, it is impossible to conceive any change at all to take place. Since, then, the distance of the particles of albumen does not, as far at least as we can perceive, change, we must conclude that the figure of the particles actually does change. Now such a change may take place three ways; 1. The figure may be changed by the addition of some new molecules to each of the molecules of the body. 2. Some molecules may be abstracted from every integrant particle of the body. 3. Or the molecules, of which the integrant particles are composed, may enter into new combinations, and form new integrant particles, whose form is different from that of the old integrant particles. Some one or other of these three things must take place during the coagulation of albumen.

1. Scheele and Fourcroy have ascribed the coagulation of albumen to the first of these causes, namely, to the addition of a new substance. According to Scheele, *caloric* is the substance which is added. Fourcroy, on the contrary, affirms that it is *oxygen*.

Scheele supported his opinion with that wonderful ingenuity which shone so eminently in every thing which he did. He mixed together one part of white of egg and four parts of water, added a little pure alkali, and then dropt in as much muriatic acid as was sufficient to saturate the alkali. The albumen coagulated; but when he repeated the experiment, and used carbonat of alkali instead of pure alkali, no coagulation ensued. In the first case, says he, there was a double decomposition: the muriatic acid separated from a quantity of caloric with which it was combined, and united with the alkali: while, at the same instant, the caloric of the acid united with the albumen, and caused it to coagulate. The same combination could not take place when the alkaline carbonat was used, because the carbonic acid gas carried off the caloric, for which it has a strong affinity *.

* Scheele, ii. 58.

This explanation is plausible; but it is contrary to every other known fact in chemistry, to suppose that caloric can combine with a substance without occasioning any alteration in its bulk, and cannot therefore be admitted without the most rigid proof.

Fourcroy observes, in support of his opinion, that the white of an egg is not at first capable of forming a hard coagulum, and that it only acquires that property by exposure to the atmosphere. It is well known that the white of a new laid egg is milky after boiling; and that if the shell be covered over with grease, to exclude the external air, it continues long in that state; whereas the white of an old egg, which has not been preserved in that manner, forms a very hard tough coagulum. These facts are undoubted; and they render it exceedingly probable, that albumen acquires the property of forming a hard coagulum only by absorbing oxygen: but they by no means prove that coagulation itself is owing to such an absorption. And since coagulation takes place without the presence of air, and since no air, even when it is present, is absorbed, this opinion cannot be maintained without inconsistency.

2. The only substance which can be supposed to leave albumen during coagulation, since it does not lose weight, is *caloric*. We know that in most cases where a fluid is converted into a solid, caloric is actually disengaged. It is extremely probable, then, that the same disengagement takes place here. But the opinion has not been confirmed by any proof. Fourcroy indeed says, that in an experiment made by him, the thermometer rose a great number of degrees. But as no other person has ever been able to observe any such thing, it cannot be doubted that this philosopher has been misled by some circumstance or other to which he did not attend †. It is usual, in many cases, for bodies to lose bulk when they give out caloric; but that there are exceptions to this rule, is well known.

† Thomson's Fourcroy, iii. 271.

3. Even if the second opinion were true, it is scarcely possible to conceive the coagulation of albumen to take place without some change in its integrant particles. We can see how all the substances which coagulate albumen might produce such a change; and the insolubility of coagulated albumen in water, and its other different properties, render it more than probable that some such change actually takes place. But what that change is, cannot even be conjectured.

The

Gelatine.

198 Properties of albumen.

The coagulation of albumen is intimately connected with one of the moſt important problems in chemiſtry, namely, the cauſe of fluidity and ſolidity. But this problem can only be reſolved, with any proſpect of ſucceſs, by a geometrical inveſtigation of the phenomena of heat.

Coagulated albumen is diſſolved by the mineral acids, greatly diluted with water; and if a concentrated acid be added to the ſolution, the albumen is again precipitated *. Alkalies, however, do not precipitate it from its ſolution in acids †. But if a ſolution of tan be poured into the acid ſolution of albumen, a very copious precipitate appears ‡.

If the ſolution of tan be poured into an aqueous ſolution of uncoagulated albumen, it forms with it a very copious precipitate, which is inſoluble in water. This precipitate is a combination of tan and albumen. This property which albumen has of precipitating with tan, was diſcovered by Seguin §: it furniſhes us with a method of detecting the preſence of albumen in any liquid in which we ſuſpect it.

* Scheele, 57.
† Vauquelin, Ann. de Chim. xxix.
‡ Ibid.
§ Nicholſon's Journal, i. 271.

Pure alkalies and lime water alſo diſſolve albumen; at the ſame time ammonia is diſengaged, owing to the decompoſition of part of the albumen. Acids precipitate the albumen from alkalies, but its properties are changed *.

Nitric acid, when aſſiſted by heat, diſengages azotic gas from albumen †; but the quantity is not ſo great as may be obtained from fibrina ‡. The albumen is gradually diſſolved, nitrous gas is emitted, oxalic and malic acids are formed, and a thick oily matter makes its appearance on the ſurface §. When diſtilled, it furniſhes the ſame products as fibrina, only the quantity of ammonia is not ſo great ‖.

Hence it follows, that albumen is compoſed of azot, hydrogen, and carbon, as well as fibrina; but the proportion of azot is not ſo great in the firſt ſubſtance as in the ſecond.

* Scheele, 57.
† Scheele and Bertholet.
‡ Fourcroy, Ann. de Chim. i. 41.
§ Scheele, Crell's Annals, ii. 17. Eng. Tranſl.
‖ Fourcroy, Ann. de Chim. i. 43.

SECT III. *Of Gelatine.*

199 Gelatine how obtained.

If a piece of the freſh ſkin of an animal, an ox for inſtance, after the hair and every impurity is carefully ſeparated, be waſhed repeatedly in cold water, till the liquid ceaſes to be coloured, or to abſtract any thing; if the ſkin, thus purified, be put into a quantity of pure water, and boiled for ſome time, part of it will be diſſolved. Let the decoction be ſlowly evaporated till it is reduced to a ſmall quantity, and then put aſide to cool. When cold, it will be found to have aſſumed a ſolid form, and to reſemble preciſely that tremulous ſubſtance well known to every body under the name of *jelly*. This is the ſubſtance called in chemiſtry *gelatine*. If the evaporation be ſtill farther continued, by expoſing the gelly to dry air, it becomes hard, ſemitranſparent, breaks with a glaſſy fracture, and is in ſhort the ſubſtance ſo much employed in different arts under the name of *glue*. Gelatine, then, is preciſely the ſame with glue; only that it muſt be ſuppoſed always free from thoſe impurities with which glue is ſo often contaminated.

200 Its properties.

Gelatine is tranſparent and colourleſs; when thrown into water, it very ſoon ſwells, and aſſumes a gelatinous form, and gradually diſſolves completely. By evaporating the water, it may be obtained again unaltered in the form of jelly.

Animal Mucilage.

When an infuſion of tan is dropt into a ſolution of gelatine in water, there is inſtantly formed a copious white precipitate, which has all the properties of leather. This precipitate is compoſed of tan and gelatine. Theſe two ſubſtances, therefore, when combined, form leather. Albumen and gelatine are the only animal ſubſtances known which have the property of combining with tan, and forming with it an inſoluble compound. They may be always eaſily detected, therefore, by means of tan; and they may be readily diſtinguiſhed from each other, as albumen alone coagulates by heat, and gelatine alone concretes into a jelly.

Gelatine is inſoluble in alcohol, and is even precipitated from water by it; but both acids and alkalies diſſolve it. Nitric acid diſengages from it a ſmall quantity of azotic gas; diſſolves it, when aſſiſted by heat, excepting an oily matter, which appears on the ſurface of the ſolution; and converts it, partly into oxalic and malic acids *.

When diſtilled, there comes over firſt water, containing ſome animal matter; the gelatine then ſwells, becomes black, emits a fetid odour, accompanied with acrid fumes: Some empyreumatic oil then comes over, and a very ſmall quantity of carbonat of ammonia: its coaly reſiduum remains behind. Theſe phenomena ſhew, that gelatine is compoſed of carbon, hydrogen, and azot; but the proportion of azot is evidently much ſmaller than in either fibrina or albumen †.

* Scheele, Crell's Ann. ii. 17. Eng. Tranſl.
† Fourcroy, Ann de Chim. i. 42.

SECT. IV. *Of Animal Mucilage.*

No word in chemiſtry is uſed with leſs accuracy than *mucilage*. It ſerves as a common name for almoſt every animal ſubſtance which cannot be referred to any other claſs.

None of the ſubſtances to which the name of *animal mucilage* has been given, have been examined with care; of courſe it is unknown whether theſe ſubſtances be the ſame or different.

201 Properties of mucilage.

Whether an animal ſubſtance poſſeſſes the following properties, it is at preſent denominated an animal mucilage by chemiſts.

1. Soluble in water.
2. Inſoluble in alcohol.
3. Neither coagulable by heat, nor concreting into a gelly by evaporation.
4. Not precipitated by the ſolution of tan.

Moſt of the ſubſtances called *mucilage* have alſo the property of abſorbing oxygen, and of becoming by that means inſoluble in water.

The mucilaginous ſubſtances ſhall be pointed out in the next chapter. In the preſent ſtate of our knowledge, any account of them here would merely be a repetition of the properties juſt mentioned.

SECT. V. *Of the Basis of Bile.*

202 Baſis of bile how obtained,

Into 32 parts of freſh ox bile pour one part of concentrated muriatic acid. After the mixture has ſtood for ſome hours, paſs it through a filter, in order to ſeparate a white coagulated ſubſtance. Pour the filtrated liquor, which has a fine green colour, into a glaſs veſſel, and evaporate it by a moderate heat. When it has arrived at a certain degree of concentration, a green coloured ſubſtance precipitates. Decant off the clear liquid, and waſh the precipitate in a ſmall quantity of pure

Baſis of Bile.

pure water. This precipitate is the *baſis of bile*, or the *reſin of bile*, as it is ſometimes called*.

203 Its properties.

The baſis of bile is of a black colour; but when ſpread out upon paper or on wood, it is green: its taſte is intenſely bitter†.

When heated to about 122°, it melts; and if the heat be ſtill farther increaſed, it takes fire, and burns with rapidity. It is ſoluble in water, both cold and hot, and ſtill more ſoluble in alcohol; but water precipitates it from that liquid‡.

It is ſoluble alſo in alkalies, and forms with them a compound which has been compared to a ſoap. Acids, when ſufficiently diluted, precipitate it both from water and alkalies without any change; but if they be concentrated, the precipitate is rediſſolved§.

When diſtilled, it furniſhes ſome ſebacic‖.

204 Combines with oxygen.

From theſe properties, it is clear that the baſis of bile has a conſiderable reſemblance to oils; but it differs from them entirely in ſeveral of its properties. The addition of oxygen, with which it combines readily, alters it ſomewhat, and brings it ſtill nearer to the claſs of oils.

In this altered ſtate, the baſis of bile may be obtained by the following proceſs. Pour oxy-muriatic acid cautiouſly into bile till that liquid loſes its green colour; then paſs it through a filter to ſeparate ſome albumen which coagulates. Pour more oxy-muriatic acid into the filtered liquid, and allow the mixture to repoſe for ſome time. The oxy-muriatic acid is gradually converted into common muriatic acid; and in the mean time the baſis of bile abſorbs oxygen, and acquires new properties. Pour into the liquid, after it has remained a ſufficient time, a little common muriatic acid, a white precipitate immediately appears, which may be ſeparated from the fluid. This precipitate is the baſis of bile combined with oxygen.

It has the colour and the conſiſtence of tallow, but ſtill retains its bitter taſte. It melts at the temperature of 104°. It diſſolves readily in alcohol, and even in water, provided it be aſſiſted by heat. Acids precipitate it from theſe ſolutions¶.

* Cadet, Mem. Par. 1767, p. 340.
† Ibid p. 341.
‡ Fourcroy, Ann. de Chim. vii. 178.
§ Cadet and Maclurg.
‖ Fourcroy.
¶ Fourcroy, Ann. de Chim. vii. 176.

Sect. VI. *Of Urea.*

105 Urea how obtained.

Evaporate, by a gentle heat, a quantity of human urine voided ſix or eight hours after a meal, till it be reduced to the conſiſtence of a thick ſyrup. In this ſtate, when put by to cool, it concretes into a cryſtalline maſs. Pour, at different times, upon this maſs four times its weight of alcohol, and apply a gentle heat; a great part of the maſs will be diſſolved, and there will remain only a number of ſaline ſubſtances. Pour the alcohol ſolution into a retort, and diſtil by the heat of a ſand bath till the liquid, after boiling ſome time, is reduced to the conſiſtence of a thick ſyrup. The whole of the alcohol is now ſeparated, and what remains in the retort cryſtallizes as it cools. Theſe cryſtals conſiſt of the ſubſtance known by the name of *urea**.

This ſubſtance was firſt deſcribed by Rouelle the Younger in 1773, under the name of the *ſaponaceous extract of urine*. He mentioned ſeveral of its properties; but very little was known concerning its nature till Fourcroy and Vauquelin publiſhed their experiments on it in 1799. Theſe celebrated chemiſts have given it the name of *urea*, which we have adopted.

* Fourcroy and Vauquelin, Ann. de Chim. xxxii. 86.

Urea.

206 Its properties.

Urea, obtained in this manner, has the form of cryſtalline plates croſſing each other in different directions. Its colour is yellowiſh white; it has a fetid ſmell, ſomewhat reſembling that of garlic or arſenic; its taſte is ſtrong and acrid, reſembling that of ammoniacal ſalts; it is very viſcid and difficult to cut, and has a good deal of reſemblance to thick honey†. When expoſed to the open air, it very ſoon attracts moiſture, and is converted into a thick brown liquid. It is extremely ſoluble in water; and during its ſolution, a conſiderable degree of cold is produced‡. Alcohol diſſolves it with facility, but ſcarcely in ſo large a proportion as water. The alcohol ſolution yields cryſtals much more readily on evaporation than the ſolution in water.

When nitric acid is dropt into a concentrated ſolution of urea in water, a great number of bright pearl coloured cryſtals are depoſited, compoſed of urea and nitric acid. No other acid produces this ſingular effect. The concentrated ſolution of urea in water is brown, but it becomes yellow when diluted with a large quantity of water. The infuſion of nut-galls gives it a yellowiſh brown colour, but cauſes no precipitate. Neither does the infuſion of tan produce any precipitate‖.

207 Its component parts.

When heat is applied to urea, it very ſoon melts, ſwells up, and evaporates, with an inſupportably fetid odour. When diſtilled, there comes over firſt benzoic acid, then carbonat of ammonia in cryſtals, ſome carbonated hydrogen gas, with traces of pruſſic acid and oil; and there remains behind a large reſiduum, compoſed of charcoal, muriat of ammonia, and muriat of ſoda. The diſtillation is accompanied with an almoſt inſupportably fetid alliaceous odour. Two hundred and eighty-eight parts of urea yield by diſtillation 200 parts of carbonat of ammonia, 10 parts of carbonated hydrogen gas, 7 parts of charcoal, and 68 parts of benzoic acid, muriat of ſoda, and muriat of ammonia. Theſe three laſt ingredients Fourcroy and Vauquelin conſider as foreign ſubſtances, ſeparated from the urine by the alcohol at the ſame time with the urea. Hence it follows, that 100 parts of urea, when diſtilled, yield

92.027	carbonat of ammonia,
4.608	carbonated hydrogen gas,
3.225	charcoal.
99.860	

Now 200 parts of carbonat of ammonia are compoſed of 86 ammonia, 90 carbonic acid gas, and 24 water. Hence it follows, that 100 parts of urea are compoſed of

39.5	oxygen,
32.5	azot,
14.7	carbon,
13.3	hydrogen.
100.0	

But it can ſcarcely be doubted, that the water which was found in the carbonat of ammonia exiſted ready formed in the urea before the diſtillation¶.

When the ſolution of urea in water is kept in a boiling heat, and new water is added as it evaporates, the urea is gradually decompoſed, a very great quantity of carbonat of ammonia is diſengaged, and at the ſame time acetous acid is formed, and ſome charcoal precipitates*.

208 Spontaneous decompoſition.

When a ſolution of urea in water is left to itſelf for ſome time, it is gradually decompoſed. A froth collects

† Fourcroy and Vauquelin, Ann. de Chim. xxxii. p. 87.
‡ Ibid. p. 88.
‖ Ibid.
¶ Ibid.
* Ibid. p. 96.

Urea. lects on its ſurface; air bubbles are emitted which have a ſtrong diſagreeable ſmell, in which ammonia and acetous acid are diſtinguiſhable. The liquid contains a quantity of acetous acid. The decompoſition is much more rapid if a little gelatine be added to the ſolution. In that caſe more ammonia is diſengaged, and the proportion of acetous acid is not ſo great*.

* Fourcroy and Vauquelin, Ann. de Chim. xxii. p. 96.

209 Action of acids.

When the ſolution of urea is mixed with one-fourth of its weight of diluted ſulphuric acid, no effervefcence takes place; but, on the application of heat, a quantity of oil appears on the ſurface, which concretes upon cooling; the liquid, which comes over into the receiver, contains acetous acid, and a quantity of ſulphat of ammonia remained in the retort diſſolved in the undiſtilled maſs. By repeated diſtillations, the whole of the urea is converted into acetous acid and ammonia†.

† Ibid. p. 94.

When nitric acid is poured upon cryſtallized urea, a violent effervefcence takes place, the mixture froths, aſſumes the form of a dark red liquid, great quantities of nitrous gas, azotic gas, and carbonic acid gas, are diſengaged. When the effervefcence is over, there remains only a concrete white matter, with ſome drops of reddiſh liquid. When heat is applied to this reſiduum, it detonates like nitrat of ammonia. Into a ſolution of urea, formed by its attracting moiſture from the atmoſphere, an equal quantity of nitric acid, of the ſpecific gravity 1.460, diluted with twice its weight of water, was added; a gentle effervefcence enſued: very gentle heat was applied, which ſupported the effervefcence for two days. There was diſengaged the firſt day a great quantity of azotic gas and carbonic acid gas; the ſecond day, carbonic acid gas, and at laſt nitrous gas. At the ſame time with the nitrous gas an odour was perceivable of the oxygenated pruſſic acid of Berthollet. At the end of the ſecond day, the matter in the retort, which was become thick, took fire, and burnt with a violent exploſion. The reſiduum contained traces of pruſſic acid and ammonia. The receiver contained a yellowiſh acid liquor, on the ſurface of which ſome drops of oil ſwam‡.

‡ Ibid. p. 97.

Muriatic acid diſſolves urea, but does not alter it. Oxy-muriatic acid gas is abſorbed very rapidly by a diluted ſolution of urea; ſmall whitiſh flakes appear, which ſoon become brown, and adhere to the ſides of the veſſel like a concrete oil. After a conſiderable quantity of oxy-muriatic acid had been abſorbed, the ſolution, left to itſelf, continued to effervefce exceeding ſlowly, and to emit carbonic acid and azotic gas. After this effervefcence was over, the liquid contained muriat and carbonat of ammonia.

210 Of alkalies.

Urea is diſſolved very rapidly by a ſolution of potaſs or ſoda; and at the ſame time a quantity of ammonia is diſengaged, the ſame ſubſtance is diſengaged when urea is treated with barytes, lime, or even magneſia. Hence it is evident, that this appearance muſt be aſcribed to the muriat of ammonia, with which it is conſtantly mixed. When pure ſolid potaſs is triturated with urea, heat is produced, a great quantity of ammonia is diſengaged. The mixture becomes brown, and a ſubſtance is depoſited, having the appearance of an empyreumatic oil. One part of urea and two of potaſs, diſſolved in four times its weight of water, when diſtilled give out a great quantity of ammoniacal water; the reſiduum contained acetite and carbonat of potaſs||.

|| Ibid.

When muriat of ſoda is diſſolved in a ſolution of urea in water, it is obtained by evaporation, not in cubic cryſtals, its uſual form, but in regular octohedrons. Muriat of ammonia, on the contrary, which cryſtallizes naturally in octohedrons, is converted into cubes, by diſſolving and cryſtallizing it in the ſolution of urea.

Such are the properties of this ſingular ſubſtance, as far as they have been aſcertained by the experiments of Fourcroy and Vauquelin. It differs from all animal ſubſtances hitherto examined, in the great proportion of azot which enters into its compoſition, and in the facility with which it is decompoſed, even by the heat of boiling water.

SECT. VII. *Of SUGAR.*

Sugar.

SUGAR has been already deſcribed in the former part of this article as a vegetable ſubſtance; nothing therefore is neceſſary here but to point out the different ſtates in which it is found in animals. It has never indeed been found in animals in every reſpect ſimilar to the ſugar of vegetables; but there are certain animal ſubſtances which have ſo many properties in common with ſugar, that they can ſcarcely be arranged under any other name. Theſe ſubſtances are,

1. Sugar of milk,
2. Honey,
3. Sugar of diabetic urine.

211 Sugar of milk.

1. The method of obtaining ſugar of milk has been already detailed in the article CHEMISTRY, nº. 488. to which we refer the reader. For an account of its properties, we are indebted to the obſervations of Mr Lichtenſtein.

When pure, it has a white colour, a ſweetiſh taſte, and no ſmell. Its cryſtals are ſemitranſparent regular parallelopipeds, terminated by four-ſided pyramids. Its ſpecific gravity, at the temperature of 55°, is 1.543. At that temperature, it is ſoluble in ſeven times its weight of water; but is perfectly inſoluble in alcohol. When burnt, it emits the odour of caromel, and exhibits preciſely the appearance of burning ſugar. When diſtilled, it yields the ſame products as ſugar, only the empyreumatic oil obtained has the odour of benzoic acid§.

§ Scheele, ii. 70.

212 Honey.

2. Honey is prepared by bees, and perhaps rather belongs to the vegetable than the animal kingdom. It has a white or yellowiſh colour, a ſoft and grained conſiſtence, a ſaccharine and aromatic ſmell; by means of alcohol, and even by water, with peculiar management, a true ſugar is obtained; by diſtillation it affords an acid phlegm and an oil, and its coal is light and ſpongy like that of the mucilages of plants. Nitric acid extracts the oxalic acid, which is entirely ſimilar to that of ſugar; it is very ſoluble in water, with which it forms a ſyrup, and like ſugar paſſes to the vinous fermentation*.

* Fourcroy.

3. The urine of perſons labouring under the diſeaſe known to phyſicians by the name of *diabetes*, yields, when evaporated, a conſiderable quantity of matter, which poſſeſſes the properties of ſugar.

SECT. VIII. *Of OILS.*

213 Fixed oils.

THE oily ſubſtances found in animals may be arranged under three heads: 1. Fixed oils; 2. Fat; 3. Spermaceti.

1. The fixed oils are obtained chiefly from different kinds of fiſh, as the whale, &c.; and they are diſtin-

Oils.

guished by the name of the animal from which they are obtained, as *whale oil*, &c. These oils agree in their properties with other fixed oils; which have been already described in the article CHEMISTRY, Part II. Chap. iii. *Suppl.*

2. *Fat*, or rather tallow, is a well known animal substance, much employed in the manufacture of candles and soap.

214 Properties of fat.

It has a white colour, often with a shade of yellow. When fresh, it has no smell, and but little taste. While cold, it is hard and brittle; but when exposed to the heat of 92°, it melts, and assumes the appearance of oil. The fat, however, which is extracted from flesh by boiling, does not melt till it reach the temperature of 127°*. Tallow and fat, in other respects, have the properties of fixed oils. They seem to be composed of a fixed oil combined with sebacic acid. When strongly heated, with contact of air, it emits a smoke of a penetrating smell, which excites tears and coughing, and takes fire when sufficiently heated to be volatilized: the charcoal it affords is not abundant. If fat be distilled on a water-bath, an insipid water, of a slight animal smell, is obtained, which is neither acid nor alkaline, but which soon acquires a putrid smell, and deposits filaments of a mucilaginous nature. This phenomenon, which takes place with the water obtained by distillation on the water bath from any animal substance, proves, that this fluid carries up with it a mucilaginous principle, which is the cause of its alteration. Fat, distilled in a retort, affords phlegm, at first aqueous, and afterwards strongly acid; an oil, partly liquid, and partly concrete; and a very small quantity of charcoal, exceedingly difficult to incinerate, in which Crell found a small quantity of phosphat of lime. These products have an acid and penetrating smell, as strong as that of sulphurous acid. The acid is the sebacic.

* *Nicholson's Journal*, i. 71.

215 Properties of spermaceti.

3. *Spermaceti*, is an oily, concrete, crystalline, semi-transparent matter, of a peculiar smell, which is taken out of the cavity of the cranium of the cachalot; it is purified by liquefaction, and the separation of another fluid and inconcrescible oil, with which it is mixed. This substance exhibits very singular chemical properties; for it resembles fixed oils in some respects, and volatile oils in others.

When heated to the temperature of 133°† it melts; and if the heat be increased, it evaporates without much alteration. When repeatedly distilled, however, it loses its solid form, and becomes like oil. When heated in contact with air, it takes fire, and burns uniformly without any disagreeable odour: hence its use in making candles.

† *Ibid.*

By long exposure in hot air it becomes yellow and rancid. Pure alkali combines with it, and forms a soap. Nitric and muriatic acids do not affect it, but sulphuric acid dissolves it and alters its colour.

SECT. IX. *Of Acids.*

THE acids hitherto discovered in the animal kingdom are the nine following.

Acids.

1. Sulphuric,	4. Carbonic,	7. Formic,
2. Muriatic,	5. Benzoic,	8. Bombyc,
3. Phosphoric,	6. Sebacic,	9. Uric.

The first eight of these have been already described in the article CHEMISTRY, *Suppl.* it is unnecessary therefore to describe them here.

216 Discovery of uric acid.

Few persons are ignorant that concretions sometimes form in the human urinary bladder, and produce that very formidable disease known by the names of the *stone* and the *gravel*. These concretions are often extracted by a surgical operation: they are called *urinary calculi*.

The most common of these calculi is of a brown colour, and very soluble in pure potass or soda ley.

If into an alkaline solution of one of these calculi a quantity of acetous acid be poured, a copious brown coloured precipitate immediately appears, which may be separated and edulcorated in a small quantity of water. This substance is *uric acid* *.

* Fourcroy *Ann. de Chim.* xvi. 116.

It was discovered by Scheele in 1776, and the French chemists afterwards called it *lithic acid*: but this name, in consequence chiefly of some remarks of Dr Pearson on its impropriety, has been lately given up, and that of *uric* (L) acid substituted in its place. We have adopted the new name, because we think it preferable to the old; which indeed conveyed a kind of inconsistency to those who attended to the etymological meaning of the word.

217 Its properties.

Uric acid possesses the following properties: it crystallizes in thin plates; has a brown colour, and scarcely any taste. Cold water scarcely dissolves any part of it; but it is soluble in 360 parts of boiling water. The solution reddens vegetable blues, especially the tincture of turnsol. A great part of the acid precipitates again as the water cools. It combines readily with alkalies and earths; but the compound is decomposed by every other acid. Sulphuric acid, when concentrated, decomposes it entirely*. Nitric acid dissolves it readily: the solution is of a pink colour, and has the property of tinging animal substances, the skin for instance, of the same colour†. When this solution is boiled, a quantity of azotic gas, carbonic acid gas, and of prussic acid, is disengaged ‡. Oxy-muriatic acid converts it in a few minutes into oxalic acid §.

* *Scheele*, i. 200.

† *Ibid.* and *Pearson.*

‡ *Fourcroy, Ann. de Chim.* xxvii. 267.

§ *Brugnatelli, ibid.* xxxii. 184.

When distilled, about a fourth of the acid passes over a little altered, and is found in the receiver crystallized in plates; a few drops of thick oil make their appearance; $\frac{1}{8}$th of the acid of concrete carbonat of ammonia, some prussiat of ammonia, some water, and carbonic acid; and there remains in the retort charcoal, amounting to about $\frac{1}{85}$th of the weight of the acid distilled ||.

|| *Fourcroy, ibid.* xvi. 116.

These facts are sufficient to shew us, that uric acid is composed of carbon, azot, hydrogen, and oxygen; and that the proportion of the two last ingredients is much smaller than of the other two.

The different salts which uric acid forms with alkaline and earthy bases have not been examined with attention; but urat of potass, of soda, and of lime, have been formed both by Scheele and Fourcroy; and urat of

(L) From *urine*; because this acid is always found in human urine.

Alkalies, Earths, and Metals.

of ammonia is not unfrequently found cryſtallized in urinary calculi.

The order of the affinities of the different baſes for uric acids is entirely unknown; but it has been aſcertained, that its affinity for theſe baſes is much weaker than that of any other acid. Its ſalts are decompoſed even by pruſſic and carbonic acid.

SECT. X. *Of ALKALIES, EARTHS, and METALS.*

1 ALL the three alkalies have been found in the animal kingdom, as we ſhall ſhew in the next chapter.

2. The only earths which have been found in animals are,

1. Lime,
2. Magneſia,
3. Silica.

The firſt in great abundance, almoſt in every large animal; the other two very rarely, and only as it were by accident.

3. The metals hitherto found in animals are,

1. Iron,
2. Manganeſe.

The firſt exiſts in all the larger animals in ſome conſiderable quantity; the ſecond has ſcarce ever been found in any quantity ſo great as to admit of being weighed.

218 Subſtances found in animals.

Such are the ſubſtances hitherto found in animals. The ſimple bodies of which all of them conſiſt are the following:

1. Azot,	6. Phoſphorus,	11. Magneſia,
2. Carbon,	7. Muriatic acid,	12. Silica,
3. Hydrogen,	8. Potaſs,	13. Iron,
4. Oxygen,	9. Soda,	14. Manganeſe.
5. Lime,	10. Sulphur,	

Of theſe, magneſia and ſilica may in a great meaſure be conſidered as foreign bodies; for they are only found in exceedingly minute quantities, and the laſt not unleſs in caſes of diſeaſe. The principal elementary ingredients are the firſt ſix: animal ſubſtances may be conſidered as in a great meaſure compoſed of them. The firſt four conſtitute almoſt entirely the ſoft parts, and the other two form the baſis of the hard parts. But we will be able to judge of this much better, after we have taken a view of the various parts of animals as they exiſt ready formed in the body. This ſhall be the ſubject of the next chapter.

CHAP. II. OF THE PARTS OF ANIMALS.

The different ſubſtances which compoſe the bodies of animals have been deſcribed with ſufficient minuteneſs in the article ANATOMY, *Encycl.* to which we beg leave to refer the reader. Any repetition in this place would be improper. Theſe ſubſtances are the following:

1. Bones and ſhells,	6. Cartilages,
2. Muſcles,	7. Skin,
3. Tendons,	8. Brain and nerves,
4. Ligaments,	9. Horns and nails,
5. Membranes,	10. Hair and feathers.

Beſides theſe ſubſtances which conſtitute the ſolid part of the bodies of animals, there are a number of fluids, the moſt important of which is the *blood*, which pervades every part of the ſyſtem in all the larger animals: The reſt are known by the name of *ſecretions*, becauſe they are formed or *ſecreted*, as the anatomiſts term it, from the blood. The principal animal ſecretions are the following:

1. Milk,	6. Mucus of the noſe,
2. Saliva,	7. Sinovia,
3. Pancreatic juice,	8. Semen,
4. Bile and biliary calculi,	9. Liquor of the amnios,
5. Tears,	10. Urine and urinary calculi.

Theſe ſubſtances ſhall form the ſubject of the following ſections.

Bones.

SECT I. *Of BONES.*

By *bones*, we mean thoſe hard, ſolid, well known ſubſtances, to which the firmneſs, ſhape, and ſtrength of animal bodies, are owing; which, in the larger animals, form, as it were, the ground-work upon which all the reſt is built. In man, in quadrupeds, and many other animals, the bones are ſituated below the other parts, and ſcarcely any of them are expoſed to view; but ſhell-fiſh and ſnails have a hard covering on the outſide of their bodies, evidently intended for defence. As theſe coverings, though known by the name of *ſhells*, are undoubtedly of a bony nature, we ſhall include them alſo in this ſection. For the very ſame reaſons, it would be improper to exclude *egg-ſhells*, and thoſe coverings of certain animals, the tortoiſe for inſtance, known by the name of *cruſts*.

It had been long known, that bones may be rendered ſoft and cartilaginous by keeping them in diluted acid ſolutions, and that ſome acids even diſſolve them altogether; that when expoſed to a violent heat, they become white, opaque, and brittle; and Dr Lewis had obſerved, that a ſudden and violent heat rendered them hard, ſemitranſparent, and ſonorous. But their component parts remained unknown till Scheele mentioned, in his diſſertation on Fluor Spar, publiſhed in the Stockholm Tranſactions for 1771, that the earthy part of bones is *phoſphat of lime* (M). Since that time conſiderable additions have been made to the chemical analyſis of theſe ſubſtances by Berniard, Bouillon, and Rouelle. Mr Hatchett has publiſhed a very valuable paper on the ſubject in the Philoſophical Tranſactions for 1799; and in the 34th volume of the *Annales de Chimie*, Mr Merat Guillot has given us a table of the component parts of the bones of a conſiderable number of animals.

The *bony parts* of animals may be divided into three claſſes; namely, *bones*, *cruſts*, and *ſhells*.

219 Properties of bones.

1. Bones have a conſiderable degree of hardneſs; when recent, they contain a quantity of marrow, which may be partly ſeparated from them. When the water in which bones have been for ſome time boiled is evaporated to a proper conſiſtence, it aſſumes the form of a *gelly*; bones therefore contain *gelatine*.

220 Their component parts.

If a piece of bone be kept for ſome time in diluted muriatic, or even acetous acid, it gradually loſes a conſiderable part of its weight, becomes ſoft, and acquires a

(M) The diſcoverer of this has not been completely aſcertained: Scheele does not claim it in that paper; Bergman gives it to Gahn; but Crell affirms that it was made by Scheele.

Bones.

a certain degree of tranſparency: and, in ſhort, acquires all the properties of *cartilage*. Bone therefore conſiſts of *cartilage*, combined with ſome ſubſtance which theſe acids are capable of diſſolving and carrying off.

If pure ammonia be dropt into the acid which has reduced the bone to this ſtate, a quantity of white powder precipitates, which poſſeſſes all the properties of *phoſphat of lime*. The ſubſtance, then, which was combined with the cartilage is *phoſphat of lime*.

After the phoſphat of lime has precipitated, the addition of carbonat of ammonia occaſions a farther precipitate, which conſiſts of carbonat of lime: but the quantity of this precipitate is inconſiderable*. When concentrated acids are poured on bones, whether recent or calcined, an efferveſcence is perceptible; the gas which eſcapes renders lime water turbid, and is therefore *carbonic acid*. Now ſince bones contain carbonic acid, and ſince they contain lime alſo uncombined with any acid ſtronger than carbonic—it is evident that they contain a little *carbonat of lime*. Mr Hatchett found this ſubſtance in all the bones of quadrupeds and of fiſh which he examined†.

* *Hatchett*, *Phil Tranſ.* 1799, p. 327.

† *Ibid.*

When bones are calcined, and the reſiduum is diſſolved in nitric acid, nitrat of barytes cauſes a ſmall precipitate, which is inſoluble in muriatic acid, and is therefore ſulphat of barytes‡. Conſequently bones contain ſulphuric acid. It has been aſcertained, that this acid is combined with lime. The proportion of *ſulphat of lime* in bones is very inconſiderable.

‡ *Ibid.*

Thus we have ſeen, that bones are compoſed of cartilage, which conſiſts almoſt entirely of gelatine, of phoſphat of lime, carbonat of lime, and ſulphat of lime. The following table, drawn up by Merat-Guillot ‖, exhibits a comparative view of the relative proportion of theſe ingredients in a variety of bones. The ſulphat of lime, which occurs only in a very ſmall quantity, has been confounded with phoſphat of lime.

‖ *Ann. de Chim* xxxiv. 71.

One hundred parts contain	Gelatine.	Phoſp. of lime	Carb. of lime	Loſs.
Human bones from a burying ground,	16	67	1.5	15.5
Do. dry, but not from under the earth,	23	63	2	2
Bone of ox, . . .	3	93	2	2
calf, . . .	25	54	trace	21
horſe, . . .	9	67.5	1.25	22.25
ſheep, . . .	16	70	0.5	13.5
elk, . . .	1.5	90	1	7.5
hog, . . .	17	52	1	30
hare, . . .	9	85	1	5
pullet, . .	6	72	1.5	20.5
pike, . . .	12	64	1	23
carp, . . .	6	45	0.5	48.5
Horſe tooth, . . .	12	85.5	0.25	2.25
Ivory, ...	24	64	0.1	11.15
Hartſhorn, ...	27	57.5	1	14.5

The enamel of the teeth is compoſed of the ſame earthy ingredients as other bones; but is totally deſtitute of cartilage*.

* *Hatchett*, *Phil Tranſ.* 1799, p. 328.

221 Component parts of cruſts.

2. The cruſtaceous coverings of animals, as of echini, crabs, lobſters, prawns, and cray fiſh, and alſo the ſhells of eggs, are compoſed of the ſame ingredients as bones; but in them the proportion of carbonat of lime far exceeds that of phoſphat*.

* *Hatchett*, *Phil. Tranſ.* 1799, p. 321, and 324.

Thus 100 parts of lobſter cruſt contain

60 carbonat of lime,
14 phoſphat,
26 cartilage,
———
100 †

One hundred parts of crawfiſh cruſt contain

60 carbonat of lime,
12 phoſphat of lime,
28 cartilage.
———
100 ‡.

† *Merat-Guillot*, *Ann de Chim.* xxxiv. 71.

‡ *Ibid.*

One hundred parts of hens egg-ſhells contain

89.6 carbonat of lime,
5.7 phoſphat of lime,
4.7 animal matter.
———
100.0 ‖.

‖ *Vauquelin*, *ibid.* xxix. 6.

Mr Hatchett found traces of phoſphat of lime alſo in the ſhells of ſnails.

222 Component parts of ſhells.

3. The ſhells of ſea animals may be divided into two claſſes: The firſt has the appearance of porcelain; their ſurface is enamelled, and their texture is often ſlightly fibrous. Mr Hatchett has given them the name of *porcellaneous* ſhells. The ſecond kind of ſhell is known by the name of *mother of pearl*. It is covered with a ſtrong epidermis, and below it lies the ſhelly matter in layers*. The ſhell of the freſh water muſcle, mother of pearl, heliotis iris, and turbo olearius, are inſtances of theſe ſhells.

* *Heriſſaut*, *Mem. Par.* 1766, p. 22.

Porcellaneous ſhells are compoſed of carbonat of lime cemented together by a very ſmall quantity of animal matter†.

Hatchett, *ibid.* 317.

† *Hatchett*, *ibid.*

Mother of pearl ſhells are compoſed of alternate layers of carbonat of lime and a thin membranaceous or cartilaginous ſubſtance. This cartilage ſtill retains the figure of the ſhell, after all the carbonat of lime has been ſeparated by acids‡.

‡ *Ibid.* 318.

Mother of pearl contains 66 carbonat of lime,
34 cartilage.
———
100 ‖

‖ *Merat-Guillot*, *ibid.*

Coral, which is a bony ſubſtance formed by certain ſea inſects, has a nearer relation to mother of pearl ſhells in its ſtructure than to any other bony ſubſtance, as the following table ¶ will ſhew.

¶ *Merat-Guillot*, *ibid.*

	White coral.	Red coral.	Articulated coraline.
Carbonat of lime,	50	53.5	49
Animal matter,	50	46.5	51
	100	100.0	100

SECT. II. *Of the* MUSCLES *of* ANIMALS.

The muſcular parts of animals are known in common language by the name of *fleſh*. They conſtitute a conſiderable proportion of the food of man.

Muſcular fleſh is compoſed of a great number of fibres or threads, commonly of a reddiſh or whitiſh colour; but its appearance is too well known to require any deſcription. Hitherto it has not been ſubjected to any accurate chemical analyſis. Mr Thouvenel, indeed, has publiſhed a very valuable diſſertation on the ſubject;

Muscles of Animals.

subject; but his analysis was made before the method of examining animal substances was so well understood as it is at present. It is to him, however, that we are indebted for almost all the facts known concerning the composition of muscle.

It is scarcely possible to separate the muscle from all the other substances with which it is mixed. A quantity of fat often adheres to it closely; blood pervades the whole of it; and every fibre is enveloped in a particular thin membranous matter, which anatomists distinguish by the name of *cellular substance*. The analysis of the muscle, then, cannot be supposed to exhibit an accurate view of the composition of pure muscular fibres, but only of muscular fibre not perfectly separated from other substances.

223 Analysis of muscles.

1. When a muscle is well washed in cold water, several of its parts are dissolved, and may be obtained by the usual chemical methods. When the water is evaporated slowly, it at last coagulates, and the coagulum may be separated by means of a filter. It possesses the properties of *albumen*.

2. The water is then to be evaporated gently to dryness, and alcohol poured upon the dry mass: part of it is dissolved by digestion, and there remains a saline substance, which has not been examined; but which Fourcroy conjectures to be a *phosphat*.

3. When the alcohol is evaporated to dryness, it leaves a peculiar mucous substance, soluble both in water and alcohol; and when its watery solution is very much concentrated, it assumes an acid and bitter taste. It swells upon hot coals, and melts, emitting an acid and penetrating smell. It attracts moisture from the air, and forms a saline efflorescence. In a hot atmosphere it becomes sour and putrefies. All these properties render it probable that this substance of Mr Thouvenel is that which is converted into *zoonic* acid during the roasting of meat.

4. The muscle is now to be boiled in water for some time. A quantity of fat appears on its surface in the form of oil, which may be taken off.

5. The water, when evaporated sufficiently, assumes the form of a jelly on cooling, and therefore contains a portion of *gelatine*. It contains also a little of the saline substance, and of the mucous substance mentioned above.

6. The residuum of the muscle is now white and insipid, of a fibrous structure, and insoluble in water, and has all the properties of *fibrina*.

Thus it appears that muscle is composed of

Albumen,
Mucous matter,
Gelatine,
Fibrina,
A salt.

The French chemists have discovered, that when a piece of muscle is allowed to remain a sufficient time in diluted sulphuric acid, it is converted into a substance resembling tallow: weak nitric acid, on the other hand, converts it into a substance resembling *wax* *.

* *Humbolt* Galvinism, 170.

SECT. III. *Of the SOFT and WHITE PARTS of ANIMALS.*

Those parts of animals to which anatomists have given the names of cartilage, tendon, ligament, membrane, differ altogether in their appearance from the muscles. They have never been analysed. We know only that they are composed, in a great measure, of *gelatine*; for it is partly from them that *glue* is made; which does not differ from gelatine, except in not being perfectly pure.

Skin.

Mr Hatchett has ascertained that they contain no phosphat of lime as a constituent part, and scarcely any saline ingredients; for when calcined they leave but a very inconsiderable residuum. Thus 250 grains of hog's bladder left only 0.02 grain of residuum †.

† *Phil. Transf.* 1799. p. 333.

SECT. IV. *Of the SKIN.*

THE skin is that strong thick covering which envelopes the whole external surface of animals. It is composed chiefly of two parts: a thin white elastic layer on the outside, which is called *epidermis* or *cuticle*; and a much thicker layer, composed of a great many fibres, closely interwoven, and disposed in different directions; this is called the *cutis*, or *true skin*. The *epidermis* is that part of the skin which is raised in blisters.

224 Epidermis.

1. The epidermis is easily separated from the cutis by maceration in hot water. It possesses a very great degree of elasticity.

225 Its properties.

It is totally insoluble in water and in alcohol. Pure fixed alkalies dissolve it completely, as does lime likewise, though slowly ‡. Sulphuric and muriatic acids do not dissolve it, at least they have no sensible action on it for a considerable time; but nitric acid soon deprives it of its elasticity, causes it to fall to pieces, and probably soon decomposes it §.

It is well known that the living epidermis is tinged yellow almost instantaneously by nitric acid; but this effect does not take place, at least so speedily, when the dead cuticle is plunged in nitric acid altogether ||.

‡ *Chaptal, Ann. de Chim.* xxii. 221.

§ *Cruikshank on Insensible Perspiration*, p. 32.

|| *Ibid.*

226 Cutis.

2. When a portion of cutis is macerated for some hours in water, and agitation and pressure is employed to accelerate the effect, the blood, and all the extraneous matter with which it was loaded, are separated from it, but its texture remains unaltered. On evaporating the water employed, a small quantity of gelatine may be obtained. No subsequent maceration in cold water has any farther effect; the weight of the cutis is not diminished, and its texture is not altered: but if it be boiled in a sufficient quantity of water, it may be completely dissolved, and the whole of it, by evaporating the water, obtained in the state of *gelatine* *.

* *Seguin, Nicholson's Journal*, i. 271.

227 Composed of gelatine.

Seguin informs us that he has ascertained, by a great variety of experiments, that the cutis differs from gelatine merely in containing an additional quantity of oxygen. Hot water (he says) expels this oxygen, and thus converts cutis into gelatine †. As these experiments have not been published, it is impossible to form any judgment of their weight.

† *Ibid.* 277.

228 Nature of tanning.

It is the skin or cutis of animals of which leather is formed. The process of converting skin into leather is called *tanning*. This process, though practised in the earliest ages, was merely empyrical, till the happy ingenuity of Mr Seguin led him to discover its real nature. After the epidermis and all the impurities of the skin have been separated, and its pores have been so far opened as to admit of being completely penetrated, it is steeped in an infusion of oak-bark, which consists of gallic acid and tan. The gallic acid (if we believe Seguin) deprives the skin gradually of oxygen, and thus converts it into gelatine, and the tan combines with this gelatine the instant it is formed; and this process goes

Brain and Nerves.

goes on so slowly that the texture of the skin is not altered. Leather, therefore, is merely a combination of gelatine and tan ‡.

‡ Nicholson's Journal, i. 171.

Sect. V. *Of the Brain and Nerves.*

The brain and nerves are the instruments of sensation, and even of motion; for an animal loses the power of moving a part the instant that the nerves which enter it are cut.

The brain and nerves have a strong resemblance to each other; and it is probable that they agree also in their composition. But hitherto no attempt has been made to analyse the nerves. The only chemists who have examined the nature of *brain* are Mr Thouret * and Mr Fourcroy †.

* Jour. de Phys. xxxviii. 329.
† Ann. de Chim. xvi. 282.

The brain consists of two substances, which differ from each other somewhat in colour, but which, in other respects, seem to be of the same nature. The outermost matter, having some small resemblance in colour to wood-ashes, has been called the *cineritious* part; the innermost part has been called the *medullary* part.

229 Properties of brain.

Brain has a soft feel, not unlike that of soap; its texture appears to be very close; its specific gravity is greater than that of water.

When brain is kept in close vessels so that the external air is excluded, it remains for a long time unaltered. Fourcroy filled a glass vessel almost completely with pieces of brain, and attached it to a pneumatic apparatus; a few bubbles of carbonic acid gas appeared at first, but it remained above a year without undergoing any farther change ‡.

‡ Ibid. 297.

This is very far from being the case with brain exposed to the atmosphere. In a few days (at the temperature of 60°) it exhales a most detestable odour, becomes acid, assumes a green colour, and very soon a great quantity of ammonia makes its appearance in it.

Cold water does not dissolve any part of the brain; but by trituration in a mortar, it forms with water a whitish coloured emulsion, which appears homogeneous, may be passed through a filter, and the brain does not precipitate by rest. When this emulsion is heated to 145°, a white coagulum is formed. The addition of a great quantity of water also causes a coagulum to appear, which swims on the surface, but the water still retains a milky colour. When sulphuric acid is dropt into the watery emulsion of brain, white flakes separate and swim on the surface, and the liquid becomes red. Nitric acid produces the same effects, only the liquid becomes yellow. Alcohol also separates a white coagulum from the emulsion, after it has been mixed with it for some hours. When nitric acid is added to the emulsion till it becomes slightly acid, a coagulum is also separated. This coagulum is of a white colour; it is insoluble in water and in alcohol. Heat softens, but does not melt it. When dried, it becomes transparent, and breaks with a glassy fracture. It has therefore some resemblance to *albumen* ‖.

‖ Ibid. 288.

When brain is triturated in a mortar with diluted sulphuric acid, part is dissolved, the rest may be separated, by filtration, in the form of a coagulum. The acid liquor is colourless. By evaporation, the liquid becomes black, sulphurous acid is exhaled, and crystals appear; and when evaporated to dryness, a black mass remains behind. When this mass is diluted with water, a quantity of charcoal separates, and the water remains clear. The brain is completely decomposed, a quantity of ammonia combines with the acid and forms sulphat of ammonia, while charcoal is precipitated. The water, by evaporation and treatment with alcohol, yields sulphats of ammonia and lime, phosphoric acid, and phosphats of soda and ammonia. Brain therefore contains

230 Its analysis.

Phosphat of lime,
——— soda,
——— ammonia.

Traces also of sulphat of lime can be discovered in it. The quantity of these salts is very small; altogether they do not amount to $\frac{1}{100}$th part ‖.

‖ Ann. de Chim. xvi. 288.

Diluted nitric acid, when triturated with brain, likewise dissolves a part, and coagulates the rest. The solution is transparent. When evaporated till the acid becomes concentrated, carbonic acid gas and nitrous gas are disengaged; an effervescence takes place, white fumes appear, an immense quantity of ammonia is disengaged, a bulky charcoal remains mixed with a considerable quantity of oxalic acid †.

† Ibid. 307.

When brain is gradually evaporated to dryness by the heat of a water bath, a portion of transparent liquid separates at first from the rest, and the residuum, when nearly dry, acquires a brown colour; its weight amounts to about one-fourth of the fresh brain. It may still be formed into an emulsion with water, but very soon separates again spontaneously.

When alcohol is repeatedly boiled upon this dried residuum till it ceases to have any more action, it dissolves about five-eighths of the whole. When this alcohol cools, it deposits a yellowish white substance, composed of brilliant plates. When kneaded together by the fingers, it assumes the appearance of a ductile paste: at the temperature of boiling water it becomes soft, and when the heat is increased it blackens, exhales empyreumatic and ammoniacal fumes, and leaves behind it a charry matter †. When the alcohol is evaporated, it deposits a yellowish black matter, which reddens paper tinged with turnsol, and readily diffuses itself through water ‡.

† Ibid. 313.
‡ Ibid. 317.

Pure concentrated potass dissolves brain, disengaging a great quantity of ammonia.

These facts are sufficient to shew us, that, exclusive of the small proportion of saline ingredients, brain is composed of a peculiar matter, differing in many particulars from all other animal substances, but having a considerable resemblance in many of its properties to albumen. Brain has been compared to a soap; but it is plain that the resemblance is very faint, as scarcely any oily matter could be extricated from brain by Fourcroy, though he attempted it by all the contrivances which the present state of chemistry suggested; and the alkaline proportion of it is a great deal too small to merit any attention.

Sect. VI. *Of Nails, Horns, Hair, Feathers.*

These substances have not hitherto been analysed. We know only that they have a great resemblance to each other. They give out the same smell, and exhibit the same phenomena when burnt, and they yield the same products when distilled.

Pure fixed alkali has the property of decomposing these substances, and of converting them into ammonia and oil. The ammonia is disengaged in great abundance, and the oil combines with the alkali, and forms a

Blood.

a species of soap. When muriatic acid is poured into the solution of these substances in pure soda, a quantity of sulphurated hydrogen gas is disengaged, and a black substance, doubtless charcoal, precipitates. Hence it follows that these substances contain in their composition a quantity of sulphur. Accordingly, if a bit of silver is put into the solution, it instantly assumes a black colour §.

These substances scarcely contain any earthy ingredients. One hundred grains of ox horn, after calcination, left only 0.04 grain of residuum, half of which was phosphat of lime Seventy eight grains of chamois horn left five grains of residuum ||.

§ Merat-Guillot, Ann. de Chim. xxxiv. ..

|| Hatchett, Phil. Trans. 1799. p. 2.

Such is a very imperfect account of the solids which compose animal bodies. We proceed next to the fluid which circulates through living bodies, namely *blood;* and to the various *secretions* formed from the blood, either in order to answer some important purpose to the animal, or to be evacuated as useless, that the blood thus purified may be more proper for answering the ends for which it is destined. Many of these substances have been examined with more care by chemists than the animal solids.

SECT. VII. *Of Blood.*

231 Properties of blood.

BLOOD is a well known fluid, which circulates in the veins and arteries of the more perfect animals. It is of a red colour, has a considerable degree of consistency, and an unctuous feel, as if it contained a quantity of soap. Its taste is slightly saline, and it has a peculiar smell.

The specific gravity of human blood is, at a medium, 1.0527 *. Mr Fourcroy found the specific gravity of bullock's blood, at the temperature of 60°, to be 1.056 †. The blood does not uniformly retain the same consistence in the same animal, and its consistence in different animals is very various. It is easy to see that its specific gravity must be equally various.

* Haller's Physiology, ii. ..

† Ann. de Chim. vii. ..

232 Composed of red globules,

When the blood is viewed through a microscope, a great many globules, of a red colour, are seen floating in it. It is to these globules that the red colour of the blood is owing. They were first examined with attention by Leuwenhoeck. Their form, their proportion, and the changes which they undergo from the addition of various substances, have been examined with the greatest care; but hitherto without adding much to our knowledge. We neither know the ingredients of which the red globules are composed, nor the changes to which they are subjected, nor the useful purposes which they serve; nor has any accurate method been discovered of separating them from the rest of the blood, and of obtaining them in a state of purity.

When blood, after being drawn from an animal, is allowed to remain for some time at rest, it very soon coagulates into a solid mass, of the consistence of curdled milk. This mass gradually separates into two parts: one of which is fluid, and is called *serum;* the other, the coagulum, has been called *cruor,* because it alone retains the red colour which distinguishes blood. This separation is very similar to the separation of curdled milk into curds and whey. The cruor usually sinks to the bottom of the vessel, and, of course, is covered by the serum.

233 ..

The cruor, or *clot* as it is sometimes called, is of a red colour, and possesses considerable consistence. Its mean specific gravity is about 1.245 ‡. If we wash the cruor in a sufficient quantity of water, it gradually loses its red colour, and assumes the appearance of a whitish, fibrous, elastic mass, which possesses all the properties of *fibrina.* The cruor therefore is composed chiefly of fibrina. The water in which it has been washed assumes a red colour, but continues transparent. It is evident from this that it contains, dissolved in it, the red globules; not, however, in a state of purity, for it is impossible to separate the cruor completely from the serum: consequently the water must contain both serum and red globules. We know, however, from this, that the red globules are soluble in water. The cruor of the blood, then, is composed of red globules and fibrina.

‡ Jurin, Haller's Physiology, ii. 41.

If the cruor of the blood be exposed to a gentle heat, it becomes gradually dry and brittle. If this dry mass be submitted to distillation, it yields water, ammonia, a thick empyreumatic oil, and much carbonat of ammonia: there remains a spongy coal of a brilliant appearance, from which sulphuric acid extracts *soda* and *iron;* there remains behind a mixture of phosphat of lime and charcoal ||.

|| Fourcroy, iii. 267.

When the fibrina is distilled, it yields precisely the same products; but the residuum contains neither iron nor soda. The red water, on the contrary, which had been employed to wash the cruor, contains both of these substances, especially iron; which may be obtained in the state of oxide by evaporating this water to dryness, and calcining the residuum ¶. These facts are sufficient to demonstrate that the red globules contain iron; consequently the opinion that their colour depends upon that metal is at least possible. It is probably owing to the soda which it contains, that the presence of iron cannot be ascertained in the solution of these globules by the usual test. The prussian alkali causes no precipitate; the infusion of nut galls gives it no blue or purplish tinge *.

¶ Ibid.

* Well's Phil. Trans. 1797.

234 And serum.

The serum is of a light greenish yellow colour; it has the taste, smell, and feel of the blood, but its consistence is not so great. Its mean specific gravity is about 1.0287 †. It converts syrup of violets to a green, and therefore contains an alkali. On examination, it is found that it owes this property to a portion of soda. When heated to the temperature of 156° §, the serum coagulates, as Harvey first discovered †. It coagulates also when boiling water is mixed with it; but if serum be mixed with six parts of cold water, it does not coagulate by heat ‡. When thus coagulated, it has a greyish white colour, and is not unlike the boiled white of an egg §. If the coagulum be cut into small pieces, a muddy fluid may be squeezed from it, which has been termed the *serosity.* After the separation of this fluid, if the residuum be carefully washed in boiling water and examined, it will be found to possess all the properties of *albumen.* The serum, therefore, contains a considerable proportion of albumen. Hence its coagulation by heat, and the other phenomena which albumen usually exhibits.

† Jurin, Haller's Physiology, ii. 41.

§ Cullen.

† De Gener. Anim. p. 161.

‡ Fourcroy, Ann. de Chim. vii. 157.

§ Ibid. 156.

If the serosity be gently evaporated till it becomes concentrated, and then be allowed to cool, it assumes the form of a jelly, as was first observed by De Haen ||. Consequently it contains *gelatine.*

|| Ibid. 157.

If serum be mixed with twice its weight of water, and, after coagulation by heat, the albumen be separated

Blood.

ted by filtration, and the liquid be flowly evaporated till it is confiderably concentrated, a number of cryftals are depofited when the liquid is left ftanding in a cool place. Thefe cryftals confift of muriat of foda and carbonat of foda ¶.

¶ Fourcroy, Ann. de Chim. vii. 155.

Thus it appears that the ferum of the blood contains albumen, gelatine, foda, muriat of foda, and carbonat of foda, befides a portion of water.

Gelatine may be precipitated from the ferofity by the three mineral acids. Mr Hunter obferved, that Goulard's extract, or, which is the fame thing, acetite of lead diffolved in acetous acid, produces with gelatine a copious precipitate ¶. When nitric acid is diffolved off ferum, it converts it partly into pruffic acid *. Acids, alcohol, and tan, precipitate the albumen in different ftates; but this, after what has been faid in the laft chapter, fection ii. requires no farther explanation.

¶ On the Blood, 35.
* Fourcroy, Ann. de Chim. vi. 180.

The proportion between the cruor and ferum of the blood varies much in different animals, and even in the fame animal in different circumftances. The moft common proportion is about one part of cruor to three parts of ferum ; but in many cafes the cruor exceeds and falls fhort of this quantity : the limits of the ratios of thefe fubftances to each other appear, from a comparifon of the conclufions of moft of thofe who have written accurately on the fubject, to be 1 : 1 and 1 : 4 ; but the firft cafe muft be very rare indeed *.

* Haller's Phyfiology, ii. 47.

When new-drawn blood is ftirred brifkly round with a ftick, or the hand, the whole of the fibrina collects together upon the ftick, and in this manner may be feparated altogether from the reft of the blood. The red globules, in this cafe, remain behind in the ferum. It is in this manner that the blood is prepared for the different purpofes to which it is put ; as clarifying fugar, making puddings, &c. After the fibrina is thus feparated, the blood no longer coagulates when allowed to remain at reft, but a fpongy flaky matter feparates from it and fwims on the furface †.

† Fourcroy, Ann. de Chim. vii. 146.

When blood is dried by a gentle heat, water exhales from it, retaining a very fmall quantity of animal matter in folution, and confequently having the odour of blood. Blood dried in this manner being introduced into a retort and diftilled, there comes over, firft a clear watery liquor, then carbonic acid gas, and carbonat of ammonia, which cryftallizes in the neck of the retort ; after thefe products there comes over a fluid oil, carbonated hydrogen gas, and an oily fubftance of the confiftence of butter. The watery liquor poffeffes the property of precipitating from fulphat of iron a green powder ; muriatic acid diffolves part of this powder, and there remains behind a little pruffian blue. Confequently this watery liquor contains both an alkali and pruffic acid ‡.

‡ Ibid. 153.

9216 grains of dried blood being put into a large crucible, and gradually heated, at firft became nearly fluid, and fwelled up confiderably, emitted a great many fetid fumes of a yellowifh colour, and at laft took fire and burned with a white flame, evidently owing to the prefence of oil. After the flame and the fumes had difappeared, a light fmoke was emitted, which affected the eyes and the nofe, which had the odour of pruffic acid, and reddened moift papers ftained with vegetable blues. At the end of fix hours, when the matter had loft five-fixths of its fubftance, it melted anew, exhibited a purple flame on its furface, and emitted a thick fmoke. This fmoke affected the eyes and noftrils, and reddened blue paper, but it had not the fmell of pruffic acid. When a quantity of it was collected and examined, it was found to poffefs the properties of phofphoric acid. The refiduum amounted to 181 grains ; it had a deep black colour, and a metallic brilliancy, and its particles were attracted by the magnet. It contained no uncombined foda, though the blood itfelf, before combuftion, contains it abundantly ; but water extracted from it muriat of foda, part of the reft was diffolved by muriatic acid, and, of courfe, was lime ; there was befides a little filica, which had evidently been feparated from the crucible. The iron had been reduced during the combuftion ‡.

‡ Fourcroy, Ann. de Chim. vii. 151.

Such are the properties of blood, as far as they have been hitherto afcertained by experiment. We have feen that it contains the following ingredients :

235 Component parts of blood.

1. Water,	5. Iron,
2. Fibrina,	6. Soda,
3. Albumen,	7. Muriat of foda,
4. Gelatine,	8. Phofphat of lime.

But our knowledge of this fingular fluid is by no means fo complete as it ought to be ; a more accurate analyfis would probably difcover the prefence of other fubftances, and enable us to account for many of the properties of blood which at prefent are inexplicable.

It would be of great confequence alfo to compare together the blood of different animals, and of the fame animal at different ages, and to afcertain in what particulars they differ from each other. This would probably throw light on fome of the obfcureft parts of the animal economy. Very little progrefs has hitherto been made in thefe refearches : if we except the labours of Rouelle, who obtained nearly the fame ingredients, though in different proportions, from the blood of a great variety of animals, the experiments of Fourcroy on the blood of the human fœtus are almoft the only ones of that kind with which we are acquainted.

236 Blood of the fœtus.

He found that it differs from the blood of the adult in three things: *1ft*, Its colouring matter is darker, and feems to be more abundant ; *2d*, It contains no fibrina, but probably a greater proportion of gelatine than blood of adults; *3d*, It contains no phofphoric acid §.

§ Ibid. 16[illegible]

237 Difeafed blood.

The examination of difeafed blood, too, would be of great confequence ; becaufe the difference of its properties from the blood of people in health might throw much light on the nature of the difeafe. It is well known, that when a perfon labours under inflammation, his blood is not fufceptible of coagulating fo foon as healthy blood. This longer time allows the red globules to fink to the bottom, and the coagulated fibrina appears at the top, of its natural whitifh colour. Hence the appearance of the *buffy coat*, as it is called, which characterizes blood during inflammation.

During that difeafe which is known by the name of *diabetes*, in which the urine is exceffive in quantity, and contains fugar, the ferum of blood often, as appears from the experiments of Dr Dobfon and Dr Rollo, affumes the appearance of whey ; and, like it, feems to contain fugar, or, at leaft, it has loft its ufualt falt tafte.

Fourcroy mentions a cafe of extreme feeblenefs, in which all the parts of the body were in an unufual relaxed ftate. In that patient a quantity of blood oozed out

Milk. out from the eye-lids, which tinged linen blue, as if it had been ftained with pruffian blue. Here pruffic alkali feems to have been formed in the blood.

Sect. VIII. *Of Milk.*

Milk is a fluid fecreted by the female of all thofe animals denominated *mammalia*, and intended evidently for the nourifhment of her offspring.

The milk of every animal has certain peculiarities which diftinguifh it from every other milk. But the animal whofe milk is moft made ufe of by man as an article of food, and with which, confequently, we are beft acquainted, is the *cow*. Chemifts, therefore, have made choice of cow's milk for their experiments. We fhall at firft confine ourfelves to the properties and analyfis of cow's milk, and afterwards point out in what refpect the milk of other animals differs from it, as far at leaft as thefe differences have hitherto been afcertained.

238 Properties of milk.

Milk is an opaque fluid, of a white colour, a flight peculiar fmell, and a pleafant fweetifh tafte. When newly drawn from the cow, it has a tafte very different from that which it acquires after it has been kept for fome hours.

It is liquid, and wets all thofe fubftances which can be moiftened by water; but its confiftence is greater than that of water, and it is flightly unctuous. Like water, it freezes when cooled down to about 30°; but Parmentier and Deyeux, to whom we are indebted for by far the completeft account of milk hitherto publifhed, found that its freezing point varies confiderably in the milk of different cows, and even of the fame cow at different times *. Milk boils alfo when fufficiently heated; but the fame variation takes place in the boiling point of different milks, though it never deviates very far from the boiling point of water. Milk is fpecifically heavier than water, and lighter than blood; but the precife degree cannot be afcertained, becaufe almoft every particular milk has a fpecific gravity peculiar to itfelf.

* *Jour. de Phyf.* xxxvii. 362.

When milk is allowed to remain for fome time at reft, there collects on its furface a thick unctuous yellowifh coloured fubftance, known by the name of *cream*. The cream appears fooner in milk in fummer than in winter, evidently owing to the difference of temperature. In fummer, about four days of repofe are neceffary before the whole of the cream collects on the furface of the liquid; but in winter it requires at leaft double the time †.

† Fourcroy, *Ann. de Chim.* vii. 67.

After the cream is feparated, the milk which remains is much thinner than before, and it has a bluifh white colour. If it be heated to the temperature of 100°, and a little *rennet*, which is water digefted with the inner coat of a calf's ftomach, and preferved with falt, be poured into it, coagulation enfues; and if the coagulum be broken, the milk very foon feparates into two fubftances: a folid white part, known by the name of *curd;* and a fluid part, called *whey*.

Thus we fee that milk may be eafily feparated into three parts; namely, *cream*, *curd*, and *whey*.

239 Cream.

Cream is of a yellow colour, and its confiftence increafes gradually by expofure to the atmofphere. In three or four days, it becomes fo thick that the veffel which contains it may be inverted without rifking any lofs. In eight or ten days more its furface is covered over with mucors and byffi, and it has no longer the flavour of cream, but of very fat cheefe *. This is the procefs for making what in this country is called a *cream cheefe*.

* Parmentier and Deyeux, *Ann. de Chim.* vii. 372.

Cream poffeffes many of the properties of an oil. It is fpecifically lighter than water, it has an unctuous feel, ftains clothes precifely in the manner of oil; and if it be kept fluid, it contracts at laft a tafte which is very analogous to the rancidity of oils †. When kept boiling for fome time, a little oil makes its appearance, and floats upon its furface ‡. Cream is neither foluble in alcohol nor oils §. Thefe properties are fufficient to fhew us that it contains a quantity of oil; but this oil is combined with a part of the curd, and mixed with fome ferum. Cream, then, is compofed of a peculiar oil, curd, and ferum. The oil may be eafily obtained feparate by agitating the cream for a confiderable time. This procefs, known to every body, is called *churning*. After a certain time, the cream feparates into two portions: one fluid, and refembling creamed milk; the other folid, and called *butter*.

† *Ibid.* 375.
‡ *Ibid.* 374.
§ *Ibid.*

240 Converted into butter,

Butter is of a yellow colour, poffeffes the properties of an oil, and mixes readily with other oily bodies. When heated to the temperature of 96°, it melts, and becomes tranfparent; if it be kept for fome time melted, fome curd and water or whey feparate from it, and it affumes exactly the appearance of oil ||. But this procefs deprives it in a great meafure of its peculiar flavour.

|| Fourcroy, *Ann. de Chim.* vii. 170.

When butter is kept for a certain time, it becomes rancid, owing in a good meafure to the prefence of thefe foreign ingredients; for if butter be well wafhed, and a great portion of thefe matters feparated, it does not become rancid nearly fo foon as when it is not treated in this manner. It was formerly fuppofed that this rancidity was owing to the developement of a peculiar acid: but Parmentier and Deyeux have fhewn that no acid is prefent in rancid butter *. When butter is diftilled, there comes over water, febacic acid, and oil, at firft fluid, but afterwards concrete. The carbonaceous refiduum is but fmall.

* *Ibid.* 375.

241 And how.

Butter may be obtained by agitating cream newly taken from milk, or even by agitating milk newly drawn from the cow. But it is ufual to allow cream to remain for fome time before it is churned. Now cream, by ftanding, acquires a four tafte; butter therefore is commonly made from four cream. Frefh cream requires at leaft four times as much churning before it yields its butter as four cream does †; confequently cream acquires, by being kept for fome time, new properties, in confequence of which it is more eafily converted into butter. When very four cream is churned, every one who has paid the fmalleft attention muft have perceived, that the butter-milk, after the churning, is not nearly fo four as the cream had been. The butter, in all cafes, is perfectly fweet; confequently the acid which had been evolved has in a great meafure difappeared during the procefs of churning. It has been afcertained, that cream may be churned, and butter obtained, though the contact of atmofpheric air be excluded ‡. We have no doubt, that in all cafes where fuch an experiment fucceeded, the cream on which it was made had previoufly become four. On the other hand, it has been afcertained, that when cream is churned in contact with air, it abforbs a confiderable quantity of it §; and it cannot

† Fourcroy, *ibid.* 169.
‡ Young *de Lacte*, 15.
§ *Mid-Lothian Report for* 1795.

Milk.

cannot be doubted, that the portion abſorbed is oxygen.

Theſe facts are ſufficient to afford us a key to explain what takes place during the proceſs of churning. There is a peculiar oil in milk, which has ſo ſtrong an affinity for the other ingredients, that it will not ſeparate from them ſpontaneouſly; but it has an affinity for oxygen, and when combined with it, forms the concrete body called *butter*. Agitation produces this combination of the oil with oxygen; either by cauſing it to abſorb oxygen from the air, or, if that be impoſſible, by ſeparating it from the acid which exiſts in ſour cream. Hence the abſorption of air during churning; hence alſo the increaſe of temperature of the cream, which Dr Young found to amount conſtantly to 4°; and hence the ſweetneſs of the butter-milk compared with the cream from which it was obtained.

The affinity of the oil of cream for the other ingredients is ſuch, that it never ſeparates completely from them. Not only is curd and whey always found in the cream, but ſome of this oil is conſtantly found in creamed milk and even in whey: for it has been aſcertained by actual experiment, that butter may be obtained by churning whey; 27 Scotch pints of whey yield at an average about a pound of butter‖. This accounts for a fact well known to thoſe who ſuperintend dairies, that a good deal more butter may be obtained from the ſame quantity of milk, provided it be churned as drawn from the cow, than when the cream alone is collected and churned.

‖ Mid-Lothian Report, 1795.

The butter-milk, as Parmentier and Deyeux aſcertained by experiment, poſſeſſes preciſely the properties of milk deprived of cream¶.

¶ Ann. de Chim. vii. 379.

272
Properties of curd.

Curd, which may be ſeparated from creamed milk by rennet, has all the properties of coagulated albumen. It is white and ſolid; and when all the moiſture is ſqueezed out, it has a good deal of brittleneſs. It is inſoluble in water; but pure alkalies and lime diſſolve it readily, eſpecially when aſſiſted by heat; and when fixed alkali is uſed, a great quantity of ammonia is emitted during the ſolution. The ſolution of curd in ſoda is of a red colour, at leaſt if heat be employed; owing probably to the ſeparation of charcoal from the curd by the action of the alkali*. Indeed, when a ſtrong heat has been uſed, charcoal precipitates as the ſolution cools†. The matter diſſolved by the alkali may be ſeparated from it by means of any acid; but it has loſt all the properties of curd. It is of a black colour, melts like tallow by the application of heat, leaves oily ſtains on paper, and never acquires the conſiſtence of curd‡. Hence it appears that curd, by the action of a fixed alkali, is decompoſed, and converted into two new ſubſtances, ammonia, and oil or rather fat.

* Ibid.

† Fourcroy, ibid. p. 175.

‡ Ibid.

Curd is ſoluble alſo in acids. If, over curd newly precipitated from milk, and not dried, there be poured eight parts of water, containing as much of any of the mineral acids as gives it a ſenſibly acid taſte, the whole is diſſolved after a little boiling§. Acetous acid and lactic acid do not diſſolve curd when very much diluted‖. But theſe acids, when concentrated, diſſolve it readily, and in conſiderable quantity¶. It is remarkable enough, that concentrated vegetable acids diſſolve curd readily, but have very little action on it when they are very much diluted: whereas the mineral diſſolve it when much diluted; but when concentrated, have either very little effect on it, as ſulphuric acid*; or decompoſe it, as nitric acid. By means of this laſt acid, as Berthollet diſcovered, a quantity of azotic gas may be obtained from curd.

§ Scheele, ii. 53.

‖ Ibid.

¶ Parmentier and Deyeux, ibid. 417. Fourcroy, ibid. p. 173.

* Parmentier, ibid.

Curd, as is well known, is uſed in making *cheeſe*; and the cheeſe is the better the more it contains of cream, or of that oily matter which conſtitutes cream. It is well known to cheeſemakers, that the goodneſs of it depends in a great meaſure on the manner of ſeparating the whey from the curd. If the milk be much heated, the coagulum broken in pieces, and the whey forcibly ſeparated, as is the practice in many parts of Scotland, the cheeſe is ſcarce good for any thing; but the whey is delicious, eſpecially the laſt ſqueezed out whey, and butter may be obtained from it in conſiderable quantity. A full proof that nearly the whole creamy part of the milk has been ſeparated with the whey. Whereas if the milk be not too much heated (about 100° is ſufficient), if the coagulum be allowed to remain unbroken, and the whey be ſeparated by very ſlow and gentle preſſure, the cheeſe is excellent; but the whey is almoſt tranſparent, and nearly colourleſs. 273 Of cheeſe.

Good cheeſe melts at a moderate heat; but bad cheeſe, when heated, dries, curls, and exhibits all the phenomena of burning horn. Hence it is evident, that all the properties in which curd differs from albumen are owing to its containing combined with it a quantity of the peculiar oil which conſtitutes the diſtinguiſhing characteriſtic of cream; hence its flavour and ſmell; and hence alſo the white colour of milk.

274
Coagulation of milk.

This ſameneſs of curd and albumen ſhews us, that the coagulation of milk and of albumen depend upon the ſame cauſe. Heat, indeed, does not coagulate milk, becauſe the albumen in it is diluted with too large a quantity of water. But if milk be boiled in contact with air, a pellicle ſoon forms on its ſurface, which has the properties of coagulated albumen: if this pellicle be removed, another ſucceeds; and by continuing the boiling, the whole of the albuminous or curdy matter may be ſeparated from milk*. When this pellicle is allowed to remain, it falls at laſt to the bottom of the veſſel, where, being expoſed to a greater heat, it becomes brown, and communicates to milk that diſagreeable taſte which, in this country, is called a *ſinged* taſte. It happens more readily when milk is boiled along with rice, flour, &c.

* Parmentier, ibid. p. 415.

If to boiling milk there be added as much of any neutral ſalt as it is capable of diſſolving, or of ſugar, or of gum arabic, the milk coagulates, and the curd ſeparates†. Alcohol alſo coagulates milk‡; as do all acids, rennet, and the infuſion of the flowers of artichoke, and of the thiſtle‖. If milk be diluted with ten times its weight of water, it cannot be made to coagulate at all¶.

† Scheele, ii. 52.

‡ Parmentier, ibid. p. 416.

‖ Ibid.

¶ Scheele, ii. 54.

275
Properties of whey.

Whey, after being filtered, to ſeparate a quantity of curd which ſtill continues to float through it, is a thin pellucid fluid, of a yellowiſh green colour and pleaſant ſweetiſh taſte, in which the flavour of milk may be diſtinguiſhed. It always contains ſome curd; but nearly the whole may be ſeparated by keeping the whey for ſome time boiling; a thick white ſcum gathers on the ſurface, which in Scotland is known by the name of *float whey*. When this ſcum, which conſiſts of the curdy part, is carefully ſeparated, the whey, after being allowed to remain at reſt for ſome hours, to give the

remainder

Milk.

remainder of the curd time to precipitate, is decanted off, almost as colourless as water, and scarcely any of the peculiar taste of milk can be distinguished in it. If it be now slowly evaporated, it deposites at last a number of white coloured crystals, which are *sugar of milk*. Towards the end of the evaporation, some crystals of muriat of potash and of muriat of lime make their appearance*. According to Scheele, it contains also a little phosphat of lime†.

After the salts have been obtained from whey, what remains concretes into a jelly on cooling‡. Hence it follows, that whey also contains *gelatine*. Whey, then, is composed of water, sugar of milk, gelatine, muriat of potash, and muriat of lime. The other salts, which are sometimes found in it, are only accidentally present.

If whey be allowed to remain for some time, it becomes sour, owing to the formation of a peculiar acid known by the name of *lactic acid*. It is to this property of whey that we are to ascribe the acidity which milk contracts; for neither curd nor cream, perfectly freed from serum, seem susceptible of acquiring acid properties. Hence the reason, also, that milk, after it becomes sour, always coagulates. Boiled milk has the property of continuing longer sweet; but it is singular enough, that it runs sooner to putrefaction than ordinary milk*.

* Parmentier, p. 417.
† Scheele, ii. 1.
‡ Rouelle.
* Parmentier, ibid. p. 43.

276 Vinegar obtained from milk.

The acid of milk differs considerably from the acetous; yet vinegar may be obtained from milk by a very simple process. If to somewhat more than 8 lbs. troy of milk, six spoonfuls of alcohol be added, and the mixture well corked be exposed to a heat sufficient to support fermentation (provided attention be paid to allow the carbonic acid gas to escape from time to time), the whey, in about a month, will be found converted into vinegar†.

† Scheele. ii. 8.

297 Milk undergoes fermentation.

Milk is almost the only animal substance which may be made to undergo the vinous fermentation, and to afford a liquor resembling wine or beer, from which alcohol may be separated by distillation. This singular fact seems to have been first discovered by the Tartars; they obtain all their spirituous liquors from mares milk. It has been ascertained, that milk is incapable of being converted into wine till it has become sour; after this, nothing is necessary but to place it in the proper temperature, the fermentation begins of its own accord, and continues till the formation of wine be completed‡. Scheele had observed, that milk was capable of fermenting, and that a great quantity of carbonic acid gas was extricated from it during this fermentation||. But he did not suspect, that the result of this fermentation was the formation of an intoxicating liquor similar to wine.

‡ Parmentier, ibid. p. 55.
|| Scheele, ii. 5.

When milk is distilled by the heat of a water bath, there comes over water, having the peculiar odour of milk; which putrifies, and consequently contains, besides mere water, some of the other constituent parts of milk. After some time, the milk coagulates¶, as always happens when hot albumen acquires a certain degree of concentration. There remains behind a thick unctuous yellowish white substance, to which Hoffman gave the name of *franchipann*. This substance, when the fire is increased, yields at first a transparent liquid, which becomes gradually more coloured; some very fluid oil comes over, then ammonia, an acid, and at last a very thick black oil. Towards the end of the process carbonated hydrogen gas is disengaged*. There remains in the retort a coal which contains carbonat of potash, muriat of potash, and phosphat of lime, and sometimes magnesia, iron, and muriat of soda†.

¶ Bouquet.
* Parmentier, ibid. p. 368.
† Mem. Med. Par. 1787 p. 606.

278 Its component parts.

Thus we see, that cow's milk is composed of the following ingredients.

1. Water,	5. Sugar of milk,
2. Oil,	6. Muriat of lime,
3. Albumen,	7. Muriat of potash,
4. Gelatine,	8. Sulphur.

The milk of all other animals, as far as it has hitherto been examined, consists nearly of the same ingredients; but there is a very great difference in their proportion.

279 Woman's milk.

WOMAN'S MILK has a much sweeter taste than cow's milk. When allowed to remain at rest for a sufficient time, a cream gathers on its surface. This cream is more abundant than in cow's milk, and its colour is usually much whiter. After it is separated, the milk is exceedingly thin, and has the appearance rather of whey, with a bluish white colour, than of creamed milk. None of the methods by which cow's milk is coagulated succeed in producing the coagulation of woman's milk*. It is certain, however, that it contains curd; for if it be boiled, pellicles form on its surface, which have all the properties of curd†. Its not coagulating, therefore, must be attributed to the great quantity of water with which the curd is diluted.

* Clark, Irish Trans. ii. 175.
† Parmentier, ibid. p. 419.

Though the cream be churned ever so long, no butter can be obtained from it; but if, after being agitated for some hours, it be allowed to remain at rest for a day or two, it separates into two parts; a fluid which occupies the inferior part of the vessel, pellucid, and colourless, like water, and a thick white unctuous fluid, which swims on the surface. The lowermost fluid contains sugar of milk and some curd; the uppermost does not differ from cream except in consistence. The oily part of the cream, then, cannot be separated by agitation from the curd‡. This cream contains a greater portion of curd than the cream of cow's milk*:

‡ Ibid.
* Ibid.

When this milk, after the curd is separated from it, is slowly evaporated, it yields crystals of sugar of milk, and of muriat of soda. The quantity of sugar is rather greater than in cow's milk. According to Haller, the sugar obtained from cow's milk is to that obtained from an equal quantity of woman's milk as 35 : 58, and sometimes as 37 : 67, and in all the intermediate ratios.

280 Its peculiarities.

Thus it appears, that woman's milk differs from that of cow's in three particulars.

1. It contains a much smaller quantity of curd.
2. Its oil is so intimately combined with its curd, that it does not yield butter.
3. It contains rather more sugar of milk.

Parmentier and Deyeux ascertained, that the quantity of curd in woman's milk increases in proportion to the time after delivery||. Nearly the same thing has been observed with respect to cow's milk.

|| Ibid. p. 42c.

281 Ass's milk.

ASS'S MILK has a very strong resemblance to human milk: it has nearly the same colour, smell, and consistence. When left at rest for a sufficient time, a cream forms upon its surface, but by no means in such abundance as in woman's milk. This cream, by very long agitation, yields a butter, which is always soft, white, and tasteless; and, what is singular, very readily mixes again with the butter-milk; but it may be again separated

Milk, Saliva.

rated by agitation, while the vessel, which contains it, is plunged in cold water. Creamed ass's milk is thin, and has an agreeable sweetish taste. Alcohol and acids separate from it a little curd, which has but a small degree of consistence. The serum yields sugar of milk and muriat of lime *.

* *Parmentier*, p. 423.

282 Its peculiarities.

Ass's milk therefore differs from cow's milk in three particulars.

1. Its cream is less abundant and more insipid.
2. It contains less curd.
3. It contains more sugar of milk: the proportion is 35 : 80.

283 Goat's milk.

Goat's milk, if we except its consistence, which is greater, does not differ much from cow's milk. Like that milk, it throws up abundance of cream, from which butter is easily obtained. The creamed milk coagulates just as cow's milk, and yields a greater quanity of curd. Its whey contains sugar of milk, muriat of lime, and muriat of soda †.

† *Ibid.* p. 425.

284 Ewes milk.

Ewe's milk resembles almost precisely that of the cow. Its cream is rather more abundant, and yields a butter which never acquires the consistence of butter from cow's milk. Its curd has a fat and viscid appearance, and is not without difficulty made to assume the consistence of the curd of cow's milk. It makes excellent cheese ‡.

‡ *Ibid.* p. 428.

285 Mares milk.

Mare's milk is thinner than that of the cow, but scarcely so thin as human milk. Its cream cannot be converted into butter by agitation. The creamed milk coagulates precisely as cow's milk, but the curd is not so abundant. The serum contains sugar of milk, sulphat of lime, and muriat of lime ‖.

‖ *Ibid.* p. 431.

Sect. IX. *Of Saliva.*

The fluid secreted in the mouth, which flows in considerable quantity during a repast, is known by the name of *saliva*. No accurate analysis has hitherto been made of it, though it possesses some very singular properties.

286 Properties of saliva.

It is a limpid fluid like water, but much more viscid: it has neither smell nor taste.

Its specific gravity, according to Hamberger, is 1.0167 *. When agitated, it froths like all other adhesive liquids; indeed it is usually mixed with air, and has the appearance of froth.

* *Haller's Phys.* vi. 52.

It neither mixes readily with water nor oil †; but by trituration in a mortar, it may be mixed so with water as to pass through a filter ‡. It has a great affinity for oxygen, absorbs it readily from the air, and gives it out again to other bodies §. Hence the reason why gold or silver, triturated with saliva in a mortar, is oxydated, as Dutenner has observed; and why the killing of mercury by oils is much facilitated by spitting into the mixture ¶. Hence also, in all probability, the reason that saliva is a useful application to sores of the skin. Dogs, and several other animals, have constantly recourse to this remedy, and with much advantage.

† *Narcessus. Haller, ibid.* p. 54.
‡ *Fordyce on Digest.* p. 51.
§ *Fourcroy, Ann. de Chim.* xxviii 262.
¶ *Ibid.*

Saliva is coagulated by oxy muriat of mercury, by alcohol, and by nitre *. Therefore, in all probability, it contains albumen and gelatine, or some analogous substances.

* *Haller's Phys.* vi. 54.

When 100 parts of saliva are distilled, there came over 80 parts of water nearly pure, then a little carbonat of ammonia, some oil, and an acid, which perhaps is the prussic. The residuum amounts to about 1.56 parts, and is composed of muriat of soda and phosphat of lime †.

Bile.

287 Tartar of the teeth.

The *tartar* of the teeth, which is a crust deposited from saliva, consists, as Fourcroy has ascertained, of phosphat of lime.

288 Pancreatic juice.

The pancreatic juice has never been examined with much attention; but it does not appear, from the experiments that have been made, to differ much from saliva.

† *Verheyen, Textor, Nuck*, &c. as quoted by Haller, *Physiol.* vi. 55.

Sect. X. *Of Bile.*

Bile is a liquid of a yellowish green colour, an unctuous feel, and bitter taste, is secreted by the liver; and in most animals considerable quantities of it are usually found collected in the gall-bladder.

Great attention has been paid to this liquid by physicians; because the ancients were accustomed to ascribe a very great number of diseases, and even affections of the mind, to its agency. The most accurate chemical analysis of it which has hitherto appeared, is that of Mr Cadet, which was published in the Memoirs of the French Academy of Sciences for the year 1767. Several important observations had been previously made on it by Boyle, Boerhaave, Verheyen, Ramsay, and Baglivi; and some facts have since been added to our chemical knowledge of bile by Maclurg and Fourcroy. The experiments have chiefly been confined to the bile of oxen, known in this country by the name of *gall*; because it is most easily procured in large quantities.

289 Properties of bile.

The specific gravity of bile seems to vary, like that of all other animal fluids. According to Hartmann, it is 1.027 *. When strongly agitated, it lathers like soap; and for this reason, as well as from a medical theory concerning its use, it has been often called an *animal soap*.

* *Haller's Phys.* vi. 546.

It mixes readily with water in any proportion, and assumes a yellow colour: but it refuses to unite with oil when the two fluids are agitated together; the instant that they are left at rest, the oil separates and swims on the surface †.

† *Ramsay, Thesaur. Med. Edin.* ii. 459.

When muriatic acid is poured upon bile, let it be ever so fresh, an odour of sulphurated hydrogen gas is constantly exhaled ‡. When on 100 parts of ox-bile four parts of strong muriatic acid are poured, the whole instantly coagulates; but in some hours the greater part becomes again fluid; and when passed through the filter it leaves 0.26 of a white matter, which has all the properties of albumen §. This matter was detected by Ramsay; who found that it could be precipitated from bile by alcohol, acetous acid, sulphat of potass, and muriat of soda *. Cadet ascertained, that 100 parts of ox-bile contain about 0.52 of albumen. It is precipitated in a state of purity by oxy muriatic acid, provided that acid be not employed in excess †.

‡ *Maclurg*, p. 10.

290 Its component parts.

§ *Cadet, Mem. Par.* 1707. p. 340.
§ *Ibid.*
* *Thesaur. Edin.* ii. 460.
† *Fourcroy, Ann. de Chim.* vii. 170.

The muriatic acid solution, after the separation of the albumen, has a fine grass-green colour. When concentrated by some hours evaporation in a glass cucurbit on hot coals, it deposites a very copious precipitate, and loses almost the whole of its green colour. By longer evaporation, a new precipitate, similar to the first, appears, and the remaining liquid assumes the colour of beer. The precipitate possesses all the properties of the *resin of bile*. In its moist state it amounts to 10.8 parts ‡. The same substances may be obtained from bile by nitric acid; but the resin in that

‡ *Cadet, ib.*

case

Bile, biliary Calculi.

cafe has a yellow colour, and its properties are fomewhat altered *.

If 100 parts of bile be gently evaporated to drynefs by a very moderate heat, the dry mafs only weighs 10 parts, and has a brownifh black colour. When expofed to a ftrong heat in a crucible, this matter fwells up, takes fire, and emits very thick fumes. The refiduum amounts to 1.09. By lixivation with water, 1.87 of cryftallized foda may be obtained †; confequently 100 parts of bile contain, according to Mr Kirwan's table, 0.403546 of pure foda. But it is evident that, by this method, part of the foda muft have been evaporated; therefore 100 parts of bile contain more than 0.403546 of foda. Befides the foda, there is found alfo a fmall portion of muriat of foda ‡.

Cadet found the refiduum, after the feparation of the falts, of a black colour: it gave fome traces of iron. He alfo obtained a calcareous falt from bile, which he confidered as a fulphat; but it is more than probable that it was phofphat of lime.

Cadet alfo obtained from bile, by evaporating the muriatic acid folution after the feparation of the refin, a falt which cryftallized in trapeziums; it had a fweetifh tafte, and was confidered by him as analogous to fugar of milk *.

Thus we fee that bile contains the following ingredients:

1. Water,	5. A fweetifh falt,
2. Refin,	6. Muriat of foda,
3. Albumen,	7. Phofphat of lime,
4. Soda,	8. Iron.

The proportion of thefe ingredients has by no means been afcertained. The prefence of iron has been denied in bile, becaufe it gives no blue precipitate with pruffic alkali, and becaufe tincture of nut-galls does not give it a black colour †. But thefe reafons are infufficient to overturn the experiment of Cadet, who actually found it in bile.

When four parts of vinegar and five of bile are mixed together, the mixture has a fweet tafte, and does not coagulate milk. The lactic acid has precifely the fame effect as vinegar ‡.

When bile is diftilled in a water bath, it affords a tranfparent watery liquor, which contracts a pretty ftrong odour, not unlike that of mufk or amber, efpecially if the bile has been kept for fome days before it is fubmitted to diftillation §. The refiduum is of a deep brownifh green; it attracts moifture from the air, and diffolves readily in water. When diftilled in a retort, it affords a watery liquor of a yellowifh colour, and impregnated with alkali, oil, carbonat of ammonia, carbonic acid, and hydrogen gas. The coaly refiduum is eafily incinerated *. Bile, expofed to a temperature between 65° and 85° foon lofes its colour and vifcidity, acquires a naufeous fmell, and depofites whitifh mucilaginous flakes After the putrefaction has made confiderable progrefs, its fmell becomes fweet, and refembles amber †. If bile be heated, and flightly concentrated by evaporation, it may be kept for many months without alteration ‡.

* Cadet, ibid. p. 343.
† Ibid. p.
‡ Ibid.
* Ibid. p.
† Macburg, 6.
‡ Ramfay, p. 462.
§ Fourcroy, 292.
* Ibid.
† Ibid.
‡ Vauquelin.

SECT. XI. *Of Biliary Calculi.*

HARD bodies fometimes form in the gall bladder, or in the duct through which the bile paffes into the inteftinal canal, and ftop up the paffage altogether. Thefe concretions have got the name of *biliary calculi* or *gall-ftones*. As they are formed in the midft of bile, and as the fubftances of which they are compofed muft be derived from the bile, it is proper to give an account of them here, becaufe their properties cannot fail to throw fome additional light on the nature of bile itfelf.

Biliary Calculi.

291 Biliary calculi of three kinds.

Biliary calculi, all of them at leaft which have been hitherto examined with attention, may be divided into three claffes.

1. The firft kind comprehends thofe which have a white colour, and a cryftallized, fhining, lamellated ftructure.

2. The fecond is dark coloured, and has precifely the appearance of infpiffated bile. Both thefe kinds are combuftible.

3. The third kind comprehends thofe gall-ftones which do not flame, but gradually wafte away at a red heat.

We fhall take a view of each of thefe kinds of biliary calculi in their order. For the greater part of the chemical knowledge which has been hitherto acquired of them, the world is chiefly indebted to Mr Fourcroy.

292 Properties of the firft.

1. The firft fpecies of biliary calculi was pointed out for the firft time by Haller, in a differtation publifhed in 1749. Walther afterwards added feveral new facts; and at laft it was accurately defcribed by Vicq d'Azyr. It is almoft always of an oval fhape, fometimes as large as a pigeon's egg, but commonly about the fize of a fparrow's; and for the moft part only one calculus (when of this fpecies) is found in the gall bladder at a time. It has a white colour; and when broken, prefents cryftalline plates or ftriæ, brilliant and white like mica, and having a foft greafy feel. Sometimes its colour is yellow or greenifh; and it has conftantly a nucleus of infpiffated bile †.

Its fpecific gravity is lower than that of water: Gren found he fpecific gravity of one 0.803 ‡.

When expofed to a heat confiderably greater than that of boiling water, this cryftallized calculus foftens and melts, and cryftallizes again when the temperature is lowered §. It is altogether infoluble in water; but hot alcohol diffolves it with facility. Alcohol, of the temperature of 167°, diffolves $\frac{1}{20}$ of its weight of this fubftance; but alcohol, at the temperature of 60°, fcarcely diffolves any of it *. As the alcohol cools, the matter is depofited in brilliant plates refembling talc or boracic acid †. It is foluble in oil of turpentine ‡. When melted, it has the appearance of oil, and exhales the odour of melted wax: when fuddenly heated, it evaporates altogether in a thick fmoke. It is foluble in pure alkalies, and the folution has all the properties of a foap. Nitric acid alfo diffolves it; but it is precipitated unaltered by water ‡.

This matter, which is evidently the fame with the cryftals which Cadet obtained from bile, and which he confidered as analogous to fugar of milk, has a ftrong refemblance to fpermaceti. Like that fubftance, it is of an oily nature, and inflammable; but it differs from it in a variety of particulars.

Since it is contained in bile, it is not difficult to fee how it may cryftallize in the gall-bladder if it happens to be more abundant than ufual; and the confequence muft

† Fourcroy, Ann. de Chim. iii. 249.
‡ Ann de Chim. v. 186.
§ Fourcroy, ibid. ii. 123.
* Ibid. p. 180.
† Ibid. iii. 256.
‡ Gren, ibid. v. 187.
‡ Fourcroy, ibid. iii. 247.

Biliary calculi, Tears. must be a gall-stone of this species. Fourcroy found a quantity of the same substance in the dried human liver *.

* Fourcroy, ibid. p. 126.

293 Of the second. 2. The second species of biliary calculus is of a round or polygonal shape, of a grey colour exteriorly, and brown within. It is formed of concentric layers of a matter which seems to be inspissated bile; and there is usually a nucleus of the white crystalline matter at the centre. For the most part there are many of this species of calculus in the gall-bladder together: indeed it is frequently filled with them. Their size is usually much smaller than that of the last species.

This is the most common kind of gall-stone. It may be considered as a mixture of inspissated bile, and of the crystalline matter which forms the first species: and the appearance of calculi of this kind must vary considerably, according to the proportion of these ingredients.

294 Of the third. 3. Concerning the third species of gall-stone, very little is known with accuracy. Dr Saunders tells us, that he has met with some gall-stones insoluble both in alcohol and oil of turpentine; some which do not flame, but become red, and consume to an ash like a charcoal †. Haller quotes several examples of similar calculi ‡.

† On the Liver, p. 112

‡ Physiol. vi. 567.

Gall-stones often occur in the inferior animals, particularly in cows and hogs; but the biliary concretions of these animals have not hitherto been examined with attention.

Sect. XII. *Of Tears.*

That peculiar fluid which is employed in lubricating the eye, and which is emitted in considerable quantities when we express grief by weeping, is known by the name of *tears*. For an accurate analysis of this fluid, chemistry is indebted to Messrs Fourcroy and Vauquelin. Before their dissertation, which was published in 1791, appeared, scarcely any thing was known about the nature of tears.

295 Properties of tears. The liquid called tears is transparent and colourless like water; it has scarcely any smell, but its taste is always perceptibly salt. Its specific gravity is somewhat greater than that of distilled water. It gives to paper, stained with the juice of the petals of mallows or violet, a permanently green colour, and therefore contains a fixed alkali *. It unites with water, whether cold or hot, in all proportions. Alkalies unite with it readily, and render it more fluid. The mineral acids produce no apparent change upon it †. Exposed to the air, this liquid gradually evaporates, and becomes thicker. When nearly reduced to a state of dryness, a number of cubic crystals form in the midst of a kind of mucilage. These crystals possess the properties of muriat of soda; only they tinge vegetable blues green, and therefore contain an excess of soda. The mucilaginous matter acquires a yellowish colour as it dries ‡.

* Fourcroy, and Vauquelin, Jour. de Phys. xxxix. 256.

† Ibid. p. 257.

‡ Ibid. p. 256.

This liquid boils like water, excepting that a considerable froth collects on its surface. If it be kept a sufficient time at the boiling temperature, $\frac{96}{100}$ parts of it evaporate in water; and there remain about .04 parts of a yellowish matter, which by distillation in a strong heat yield water and a little oil: the residuum consists of different saline matters §.

§ Ibid.

When alcohol is poured into this liquid, a mucilaginous matter is precipitated in the form of large white flakes. The alcohol leaves behind it, when evaporated, traces of muriat of soda and soda. The residuum which remains behind, when inspissated tears are burnt in the open air, exhibits some traces of phosphat of lime and phosphat of soda ‖.

‖ Fourcroy and Vauquelin, Jour. de Phys. p. 259.

296 Component parts. Thus it appears that tears are composed of the following ingredients:

1. Water,	4. Soda,
2. Mucilage,	5. Phosphat of lime,
3. Muriat of soda,	6. Phosphat of soda.

The saline parts amount only to about 0.01 of the whole, or probably not so much.

The *mucilage* contained in the tears has the property of absorbing oxygen gradually from the atmosphere, and of becoming thick and viscid, and of a yellow colour. It is then insoluble in water, and remains long suspended in it without alteration. When a sufficient quantity of oxy-muriatic acid is poured into tears, a yellow flaky precipitate appears absolutely similar to this inspissated mucilage. The oxy-muriatic acid loses its peculiar odour; hence it is evident that it has given out oxygen to the mucilage. The property which this mucilage has of absorbing oxygen, and of acquiring new qualities, explains the changes which take place in tears which are exposed for a long time to the action of the atmosphere, as is the case in those persons who labour under a fistula lachrymalis *.

* Ibid. p. 257.

297 Mucus of the nose. The mucus of the nose has also been examined by Fourcroy and Vauquelin. They found it composed of precisely the same ingredients with the tears. As this fluid is more exposed to the action of the air than the tears, in most cases its mucilage has undergone less or more of that change which is the consequence of the absorption of oxygen. Hence the reason of the greater viscidity and consistence of the mucus of the nose; hence also the great consistence which it acquires during colds, where the action of the atmosphere is assisted by the increased action of the parts †.

† Ibid. p. 259.

Sect. XIII. *Of Sinovia.*

Within the capsular ligament of the different joints of the body, there is contained a peculiar liquid, intended evidently to lubricate the parts, and to facilitate their motion. This liquid is known among anatomists by the name of *sinovia*.

Whether it be the same in different animals, or even in all the different joints of the same animal, has not been determined; as no accurate analysis of the sinovia of different animals has been attempted. The only analysis of sinovia which has hitherto appeared is that by Mr Margueron, which was published in the 14th volume of the *Annales de Chimie*. He made use of sinovia obtained from the joints of the lower extremities of oxen.

298 Sinovia of the ox. The sinovia of the ox, when it has just flowed from the joint, is a viscid semitransparent fluid, of a greenish white colour, and a smell not unlike frog spawn. It very soon acquires the consistence of jelly; and this happens equally whether it be kept in a cold or a hot temperature, whether it be exposed to the air or excluded from it. This consistence does not continue long; the sinovia soon recovers again its fluidity, and at the same time deposites a thready-like matter *.

* Margueron, Ann. de Chim. xiv. 124.

299 Its properties. Sinovia mixes readily with water, and imparts to that liquid a great deal of viscidity. The mixture froths when agitated; becomes milky when boiled, and deposites

sinovia, semen. fites some pellicles on the sides of the dish; but its viscidity is not diminished †.

Margueron, Ann. Chim. p. 106. When alcohol is poured into sinovia, a white substance precipitates, which has all the properties of albumen. One hundred parts of sinovia contain 4.52 of albumen. The liquid still continues as viscid as ever;
300 component parts. but if acetous acid be poured into it, the viscidity disappears altogether, the liquid becomes transparent, and deposites a quantity of matter in white threads, which possesses the following properties:

1. It has the colour, smell, taste, and elasticity of vegetable gluten.

2. It is soluble in concentrated acids and pure alkalies.

3. It is soluble in cold water, the solution frothes; acids and alcohol precipitate the fibrous matter in flakes. One hundred parts of sinovia contain 11.86 of this matter ‡.

Ibid. p. —130. When the liquid, after these substances have been separated from it, is concentrated by evaporation, it deposites crystals of acetite of soda. Sinovia, therefore, contains *soda*. Margueron found that 100 parts of sinovia contained about 0.71 of soda.

When strong sulphuric, muriatic, nitric, acetic, or sulphurous acid is poured into sinovia, a number of white flakes precipitate at first, but they are soon redissolved, and the viscidity of the liquid continues. When these acids are diluted with five times their weight of water, they diminish the transparency of sinovia, but not its viscidity; but when they are so much diluted that their acid taste is just perceptible, they precipitate the peculiar thready matter, and the viscidity of the sinovia disappears §.

When sinovia is exposed to a dry atmosphere it gradually evaporates, and a scaly residuum remains, in which cubic crystals, and a white saline efflorescence, are apparent. The cubic crystals are muriat of soda. One hundred parts of sinovia contain about 1.75 of this salt. The saline efflorescence is carbonat of soda ||.

Sinovia soon putrefies in a moist atmosphere, and during the putrefaction ammonia is exhaled. When sinovia is distilled in a retort there comes over, first water, which soon putrefies; then water containing ammonia; then empyreumatic oil and carbonat of ammonia. From the residuum muriat and carbonat of soda may be extracted by lixiviation. The coal contains some phosphat of lime ¶.

From the analysis of Mr Margueron it appears that sinovia is composed of the following ingredients:

11.86	fibrous matter,
4.52	albumen,
1.75	muriat of soda,
.71	soda,
.70	phosphat of lime (N),
80.57	water,
100.00.	

Sect. XIV. *Of Semen.*

The peculiar liquid secreted in the testes of males, and destined for the impregnation of females, is known by the name of *semen*. The human semen alone has hitherto been subjected to chemical analysis. Nothing is known concerning the seminal fluid of other animals. Vauquelin published an analysis of the human semen in 1791.

301 Properties of semen. Semen, when newly ejected, is evidently a mixture of two different substances: the one, fluid and milky, which is supposed to be secreted by the prostate gland; the other, which is considered as the true secretion of the testes, is a thick mucilaginous substance, in which numerous white shining filaments may be discovered *. It has a slight disagreeable odour, an acrid irritating taste, and its specific gravity is greater than that of water. When rubbed in a mortar it becomes frothy, and of the consistence of pomatum, in consequence of its enveloping a great number of air bubbles. It converts paper stained with the blossoms of mallows or violets to a green colour, and consequently contains an alkali †.

As the liquid cools, the mucilaginous part becomes transparent, and acquires greater consistency; but in about twenty minutes after its emission, the whole becomes perfectly liquid. This liquefaction is not owing to the absorption of moisture from the air, for it loses instead of acquiring weight during its exposure to the atmosphere; nor is it owing to the action of the air, for it takes place equally in close vessels ‡.

Semen is insoluble in water before this spontaneous liquefaction, but afterwards it dissolves readily in it. When alcohol or oxy-muriatic acid is poured into this solution, a number of white flakes are precipitated §. Concentrated alkalies facilitate its combination with water. Acids readily dissolve the semen, and the solution is not decomposed by alkalies; neither indeed is the alkaline solution decomposed by acids ||.

Lime disengages no ammonia from fresh semen; but after that fluid has remained for some time in a moist and warm atmosphere, lime separates a great quantity from it. Consequently ammonia is formed during the exposure of semen to air ¶.

302 Its component parts. When oxy-muriatic acid is poured into semen, a number of white flakes precipitate, and the acid loses its peculiar odour. These flakes are insoluble in water, and even in acids. If the quantity of acid be sufficient, the semen acquires a yellow colour. Thus it appears that semen contains a mucilaginous substance, analogous to that of the tears, which coagulates by absorbing oxygen. Mr Vauquelin obtained from 100 parts of semen six parts of this mucilage.

When semen is exposed to the air about the temperature of 60°, it becomes gradually covered with a transparent pellicle, and in three or four days deposites small transparent crystals, often crossing each other in such a manner as to represent the spokes of a wheel. These crystals, when viewed through a microscope, appear to be four-sided prisms, terminated by very long four-sided pyramids. They may be separated by diluting the liquid with water, and decanting it off. They have all the properties of phosphat of lime *. If, after the appearance of these crystals, the semen be still allowed to remain exposed to the atmosphere, the pellicle on

† Ibid. p. 125.

‡ Ibid. p. —130.

§ Ibid. p.

|| Ibid. 125.

¶ Ibid. 128.

* Vauquelin, Ann. de Chim. ix. 64.

† Ibid. p. 65.

‡ Ibid. p. 66.

§ Ibid. p. 70.

|| Ibid. p. 71.

¶ Ibid.

* Ibid. p. 67 and 73.

(N) Mr Hatchett found only 0.208 of phosphat of lime in the sinovia which he examined. He found, however, traces of some other phosphat; probably phosphat of soda. *Phil. Trans.* 1799, p. 246.

Semen, Liquor of the Amnios.

on its furface gradually thickens, and a number of white round bodies appear on different parts of it. Thefe bodies alfo are phofphat of lime, prevented from cryftallizing regularly by the too rapid abftraction of moifture. Mr Vauquelin found that 100 parts of femen contain three parts of phofphat of lime †. If at this period of the evaporation the air becomes moift, other cryftals appear in the femen, which have the properties of carbonat of foda. The evaporation does not go on to complete exficcation, unlefs at the temperature of 77°, and when the air is very dry. When all the moifture is evaporated, the femen has loft 0.9 of its weight, the refiduum is femi-tranfparent like horn, and brittle ‡.

† Vauquelin, Ann. de Chim. p. 68.

‡ Ibid.

When femen is kept in very moift air, at the temperature of about 7-°, it acquires a yellow colour, like that of the yolk of an egg: its tafte becomes acid, it exhales the odour of putrid fifh, and its furface is covered with abundance of the byffus feptica §.

§ Ibid.

When dried femen is expofed to heat in a crucible, it melts, acquires a brown colour, and exhales a yellow fume, having the odour of burnt horn. When the heat is raifed, the matter fwells, becomes black, and gives out a ftrong odour of ammonia. When the odour of ammonia difappears, if the matter be lixiviated with water, an alkaline folution may be obtained, which, by evaporation, yields cryftals of carbonat of foda. Mr Vauquelin found that 100 parts of femen contain one part of foda ¶. If the refiduum be incinerated, there will remain only a quantity of white afhes, confifting of phofphat of lime.

¶ Ibid. p. 75.

Thus it appears that femen is compofed of the following ingredients:

90	water,
6	mucilage,
3	phofphat of lime,
1	foda,
100	

Sect. XV. *Liquor of the Amnios.*

The fœtus in the uterus is enveloped in a peculiar membranous covering, to which anatomifts have given the name of *amnios*. Within this amnios there is a liquid, diftinguifhed by the name of the *liquor of the amnios*, which furrounds the fœtus on every part. This liquid, as might have been expected, is very different in different animals, at leaft the liquor amnii in women and in cows, which alone have hitherto been analyfed, have not the fmalleft refemblance to each other. Thefe two liquids have been lately analyfed by Vauquelin and Buniva, and the refult of their analyfis has been publifhed in the 33d volume of the *Annales de Chimie*.

303 Liquor of the human amnios.

1. The liquor of the amnios of women is a fluid of a flightly milky colour, a weak but pleafant odour, and a faltifh tafte. The white colour is owing to a curdy matter fufpended in it, for it may be obtained quite tranfparent by filtration *.

* Ann. de Chim. xxxiii. 270.

Its fpecific gravity is 1.005. It gives a green colour to the tincture of violets, and yet it reddens very decidedly the tincture of turnfol. Thefe two properties would indicate at once the prefence of an acid and of an alkali. It frothes confiderably when agitated. On the application of heat it becomes opaque, and has then a great refemblance to milk diluted with a large quantity of water. At the fame time it exhales the odour of boiled white of egg *.

* Ann. de Chim. xxx 271.

Acids render it more tranfparent. Alkalies precipitate an animal matter in fmall flakes. Alcohol likewife produces a flaky precipitate, which, when collected and dried, becomes tranfparent, and very like glue. The infufion of nut-galls produces a very copious brown coloured precipitate. Nitrat of filver occafions a white precipitate, which is infoluble in nitric acid, and confequently is muriat of filver †.

† Ibid.

When flowly evaporated it becomes flightly milky, a tranfparent pellicle forms on its furface, and it leaves a refiduum which does not exceed 0.012 of the whole. By lixiviating this refiduum, and evaporating the ley, cryftals of muriat and carbonat of foda may be obtained. The remainder, when incinerated, exhales a fetid and ammoniacal odour, refembling that of burning horn; the afhes confift of a fmall quantity of carbonat of foda, and of phofphat and carbonat of lime ‡.

‡ Ibid. p. 272.

Thus we fee that the liquor of the human amnios is compofed of about

$$\begin{array}{l} 98.8 \text{ water,} \\ 1.2 \left\{ \begin{array}{l} \text{albumen,} \\ \text{muriat of foda, foda,} \\ \text{phofphat of lime, lime,} \end{array} \right. \\ \hline 100.0 \end{array}$$

304 Curdy matter depofited on the fœtus.

While the fœtus is in the uterus, a curdy-like matter is depofited on the furface of its fkin, and in particular parts of its body. This matter is often found collected in confiderable quantities. It is evidently depofited from the liquor of the amnios; and confequently the knowledge of its peculiar nature muft throw confiderable light upon the properties and ufe of that liquor. For an analyfis of this fubftance we are alfo indebted to Vauquelin and Buniva.

Its colour is white and brilliant; it has a foft feel, and very much refembles newly prepared foap. It is infoluble in water, alcohol, and oils. Pure alkalies diffolve part of it, and form with it a kind of foap. On burning coals it decrepitates like a falt, becomes dry and black, exhales vapours which have the odour of empyreumatic oil, and leaves a refiduum, which is very difficultly reduced to afhes. When heated in a platinum crucible it decrepitates, lets an oil exfude, curls up like horn, and leaves a refiduum confifting chiefly of carbonat of lime ‡.

‡ Ibid. p. 274.

Thefe properties fhew that this matter is different from every one of the component parts of the liquor of the amnios, and that it has a great refemblance to the *fat*. It is probable, as Vauquelin and Buniva have conjectured, that it is formed from the albumen of that liquid, which has undergone fome unknown changes. It has been long known, that the parts of a fœtus which has lain for fome time after it has been deprived of life in the uterus, are fometimes converted into a kind of fatty matter. It is evident that this fubftance, after it is depofited upon the fkin of the fœtus, muft preferve it in a great meafure from being acted upon by the liquor of the amnios.

30[5] Liquor of the amnios of the cow.

2. The liquor of the amnios of the cow has a vifcidity fimilar to mucilage of gum arabic, a brownifh red colour, an acid and bitter tafte, and a peculiar odour, not unlike that of fome vegetable extracts. Its fpecific gravity is 1.028. It reddens the tincture of turnfol, and

Liquor of the Amnios. and therefore contains an acid. Muriat of barytes causes a very abundant precipitate, which renders it probable that it contains sulphuric acid. Alcohol separates from it a great quantity of a reddish coloured matter *.

* Ann. de Chim xxxiii. 275

306 Its component parts. When this liquid is evaporated, a thick frothy scum gathers on the surface, which is easily separated, and in which some white acid-tasted crystals may be discovered. By continuing the evaporation, the matter becomes thick, and viscid, and has very much the look of honey. Alcohol boiled upon this thick matter, and filtered off, deposites upon cooling brilliant needle-formed crystals nearly an inch in length. These crystals may be obtained in abundance by evaporating the liquor of the amnios to a fourth part of its bulk, and then allowing it to cool. The crystals soon make their appearance. They may be separated and purified by washing them in a small quantity of cold water. These crystals have the properties of an acid §.

§ Ibid. p.

If after the separation of this acid the liquor of the amnios be evaporated to the consistence of a syrup, large transparent crystals appear in it, which have all the properties of sulphat of soda. The liquid of the amnios of cows contains a considerable quantity of this salt.

Thus it appears that the liquor of the amnios of cows contains the following ingredients:

1. Water,
2. A peculiar animal matter,
3. A peculiar acid,
4. Sulphat of soda.

307 Nature of the animal matter. The animal matter possesses the following properties: It has a reddish brown colour, and a peculiar taste; it is very soluble in water, but insoluble in alcohol, which has the property of separating it from water. When exposed to a strong heat it swells, exhales first the odour of burning gum, then of empyreumatic oil and of ammonia, and at last the peculiar odour of prussic acid becomes very conspicuous. It differs from gelatine in the viscidity which it communicates to water, in not forming a jelly when concentrated, and in not being precipitated by tan. It must be therefore ranked among the very undefined and inaccurate class of *animal mucilages*.

When burnt, it leaves a very large coal, which is readily incinerated, and leaves a little white ashes, composed of phosphat of magnesia, and a very small proportion of phosphat of lime ‖.

‖ Ibid. p.

308 Amniotic acid. The acid substance is of a white and brilliant colour; its taste has a very slight degree of sourness; it reddens the tincture of turnsol; it is scarcely soluble in cold water, but very readily in hot water, from which it separates in long needles as the solution cools. It is soluble also in alcohol, especially when assisted by heat. It combines readily with pure alkalies, and forms a substance which is very soluble in water. The other acids decompose this compound; and the acid of the liquor of the amnios is precipitated in a white crystalline powder. This acid does not decompose the alkaline carbonats at the temperature of the atmosphere, but it does so when assisted by heat. It does not alter solutions of silver, lead, or mercury, in nitric acid. When exposed to a strong heat, it frothes and exhales an odour of ammonia and of prussic acid. The properties are sufficient to shew that it is different from every other acid. Vauquelin and Boniva have given it the name of *amniotic acid*. It approaches nearest to the saccholactic and the *uric* acids; but the sachlactic acid does not furnish ammonia by distillation like the amniotic. The uric acid is not so soluble in hot water as the amniotic, it does not crystallize in white brilliant needles, and it is insoluble in boiling alcohol; in both which respects it differs completely from amniotic acid *.

* Ann. de Chim. xxxiii. p. 279.

Sect. XVI. *Of Urine*.

309 Urine. No animal substance has attracted more attention than urine, both on account of its supposed connection with various diseases, and on account of the very singular products which have been obtained from it. Mr Boyle, and the other chemists who were his contemporaries, were induced to attend particularly to this liquid, by the discovery of a method of obtaining phosphorus from it. Boerhaave, Haller, Haupt, Margraf, Pott, Rouelle, Proust, and Klaproth, successively improved the method of obtaining the phosphoric salts from urine, or added something to our knowledge of the component parts of these salts. Scheele added greatly to our knowledge of urine by detecting several new substances in it which had not been suspected. Cruickshank has given us a very valuable paper on urine in the second edition of *Rollo's Diabetes*; and Fourcroy and Vauquelin have lately published the most complete analysis of it which has hitherto appeared.

Fresh urine is a liquid of a peculiar aromatic odour, an orange colour, of greater or less intensity, and an acrid saline taste.

Its specific gravity varies from 1.005 to 1.033 *.

* Cruickshank, Phil. Mag. ii. 240.

1. It reddens paper stained with turnsol and with the juice of radishes, and therefore contains an acid.

310 Contains phosphat of lime. 2. If a solution of ammonia be poured into fresh urine, a white powder precipitates, which has the properties of phosphat of lime. The presence of this substance in urine was first discovered by Scheele †. If lime water be poured into urine, phosphat of lime precipitates in greater abundance than when ammonia is used; consequently the acid which urine contains is the phosphoric. Thus we see that the phosphat of lime is kept dissolved in urine by an excess of acid. This also was first discovered by Scheele ‡. This substance is most abundant in the urine of the sick. Berthollet has observed that the urine of gouty people is less acid than that of people in perfect health. The average quantity of phosphat of lime in healthy urine is, as Cruickshank has ascertained, about $\frac{1}{900}$ of the weight of the urine §.

† Scheele, i. 208.

‡ Ibid.

§ Phil. Mag. ii. 241.

311 Phosphat of magnesia. 3. If the phosphat of lime precipitated from urine be examined, a little magnesia will be found mixed with it. Fourcroy and Vauquelin have ascertained that this is owing to a little phosphat of magnesia which urine contains, and which is decomposed by the alkali or lime employed to precipitate the phospat of lime ¶.

¶ Ann. de Chim. xxxi. 66.

312 Uric acid. 4. When fresh urine cools, it often lets fall a brick coloured precipitate, which Scheele first ascertained to be crystals of uric acid. All urine contains this acid, even when no sensible precipitate appears when it cools. For if a sufficient quantity of clear and fresh urine be evaporated to $\frac{1}{118}$ of its weight, a subtle powder precipitates to the bottom, and attaches itself in part very firmly to the vessel. This part may be dissolved in pure alkali, and precipitated again by acetous acid. It exhibits all the properties of uric acid *. The quantity of uric acid in urine is very various. During intermittent

* Scheele, i. 207.

Urine.

termittent fevers it is depofited very copioufly, and has been long known to phyficians under the name of *lateritious fediment*. This fediment always makes its appearance at the crifis of fevers. In gouty people, the fame fediment appears in equal abundance towards the end of a paroxyfm of the difeafe (P). And if this fediment fuddenly difappears after it has begun to be depofited, a frefh attack may be expected*.

* *Cruikfhank, Phil. Mag.* ii. 249.

313 Benzoic acid,

5. If frefh urine be evaporated to the confiftence of a fyrup, and muriatic acid be then poured into it, a precipitate appears which poffeffes the properties of benzoic acid. Scheele firft difcovered the prefence of benzoic acid in urine. He evaporated it to drynefs, feparated the faline part, and applied heat to the refiduum. The benzoic acid was fublimed, and found cryftallized in the receiver. The method which we have given is much eafier; it was firft propofed by Fourcroy and Vauquelin†. By it very confiderable quantities of benzoic acid may be obtained from the urine of horfes and cows, where it is much more abundant than in human urine. In human urine it varies from $\frac{1}{1000}$ to $\frac{1}{1055}$ of the whole§.

† *Ann. de Chim.* xxxi. 62.

§ *Ibid.* p. 63.

314 Albumen and gelatine,

6. When an infufion of tan is dropt into urine, a white precipitate appears, having the properties of the combination of tan and albumen, or gelatine. Urine, therefore, contains albumen and gelatine. Thefe fubftances had been fufpected to be in urine, but their prefence was firft demonftrated by Seguin, who difcovered the above method of detecting them. Their quantity in healthy urine is very fmall. Cruikfhank found that the precipitate afforded by tan in healthy urine amounted to $\frac{1}{240}$th part of the weight of the urine‡. It is to thefe fubftances that the appearance of the *cloud*, as it is called, or the mucilaginous matter, which is fometimes depofited as the urine cools, is owing. It is probable that healthy urine contains only gelatine and not albumen, though the quantity is too fmall to admit of accurate examination; but in many difeafes the quantity of thefe matters is very much increafed. The urine of dropfical people often contains fo much albumen, that it coagulates not only on the addition of acids, but even on the application of heat§. In all cafes of impaired digeftion, the albuminous and gelatinous part of urine is much increafed. This forms one of the moft confpicuous and important diftinctions between the urine of thofe who enjoy good and bad health‖.

‡ *Phil. Mag.* ii. 243.

§ *Cruikfhank, ibid.* 248.

‖ *Fourcroy and Vauquelin, Ann. de Chim.* xxxi. 61.

315 Urea,

7. If urine be evaporated by a flow fire to the confiftence of a thick fyrup, it affumes a deep brown colour, and exhales a fetid ammoniacal odour. When allowed to cool, it concretes into a mafs of cryftals, compofed of all the component parts of urine. If four times its weight of alcohol be poured upon this mafs, at intervals, and a flight heat be applied, the greateft part of it is diffolved. The alcohol, which has acquired a brown colour, is to be decanted off, and diftilled in a crucible in a fand heat, till the mixture has boiled for fome time, and acquired the confiftence of a fyrup. By this time the whole of the alcohol has paffed off, and the matter, on cooling, cryftallizes in quadrangular plates which interfect each other. This fubftance is *urea*, which compofes $\frac{19}{20}$ of the urine, provided the watery part be excluded. To this fubftance the tafte, fmell, and colour of urine are owing. It is a fubftance which characterizes urine, and conftitutes it what it is, and to which the greater part of the very fingular phenomena of urine are to be afcribed.

The colour of urine depends upon the urea; the greater the quantity, the deeper is the colour. It may be detected by evaporating urine to the confiftence of a fyrup, and pouring into it concentrated nitric acid. Immediately a great number of white fhining cryftals appear in the form of plates, very much refembling cryftallized boracic acid. Thefe cryftals are urea combined with nitric acid.

The quantity of urea varies exceedingly in different urines. In the urine voided foon after a meal, very little of it is to be found, and fcarcely any at all in that which hyfterical patients void during a paroxyfm.

316 Muriat of foda,

8. If urine be flowly evaporated to the confiftence of a fyrup, a number of cryftals make their appearance in it. Two of thefe are remarkable by their form: one of them confifts of fmall regular octahedrons; which, when examined, are found to poffefs the properties of muriat of foda. Urine, therefore, contains muriat of foda. It is well known that muriat of foda cryftallizes in cubes; the fingular modification of its form in urine is owing to the action of urea. It has been long known that urine faturated with muriat of foda depofites that falt in regular octahedrons.

317 Muriat of ammonia,

9. Another of the falts which appear during the evaporation of urine has the form of regular cubes. This falt has the properties of muriat of ammonia. Now the ufual form of the cryftals of muriat of ammonia is the octahedron. The change of its form in urine is produced alfo by urea.

318 Phofphats of ammonia and of foda,

10. The faline refiduum which remains after the feparation of urea from cryftallized urine by means of alcohol, has been long known under the names of fufible falt of urine and microcofmic falt. Various methods of obtaining it have been given by chemifts from Boerhaave, who firft publifhed a procefs, to Rouelle and Chaulnes, who gave the method juft mentioned. If this faline mafs be diffolved in a fufficient quantity of hot water, and allowed to cryftallize fpontaneoufly in a clofe veffel, two fets of cryftals are gradually depofited. The lowermoft fet has the figure of flat rhomboidal prifms; the uppermoft, on the contrary, has the form of rectangular tables. Thefe two may be eafily feparated by expofing them for fome time to a dry atmofphere. The rectangular tables efflorefce and fall to powder, but the rhomboidal prifms remain unaltered.

When thefe falts are examined, they are found to have the properties of phofphats. The rhomboidal prifms confift of phofphat of ammonia united to a little phofphat of foda; the rectangular tables, on the contrary,

(P) The concretions which fometimes make their appearance in gouty joints have been found to confift chiefly of uric acid. This fingular coincidence deferves the attention of phyfiologifts: it cannot fail, fooner or later, to throw light, not only upon gout, but upon fome of the animal functions.

Urine.

trary, are phosphat of soda united to a small quantity of phosphat of ammonia. Urine, then, contains phosphat of soda and phosphat of ammonia.

Thus we have found that urine contains the twelve following substances:

1. Water,	7. Gelatine and albumen,
2. Phosphoric acid,	8. Urea,
3. Phosphat of lime,	9. Muriat of soda,
4. Phosphat of magnesia,	10. Muriat of ammonia,
5. Uric acid,	11. Phosphat of soda,
6. Benzoic acid,	12. Phosphat of ammonia.

319
[So]metimes [ot]her salts.

These are the only substances which are constantly found in healthy urine *; but it contains also occasionally other substances. Very often muriat of potash may be distinguished among the crystals which form during its evaporation. The presence of this salt may always be detected by dropping cautiously some tartarous acid into urine. If it contains muriat of potash there will precipitate a little tartar, which may easily be recognised by its properties *.

Urine sometimes also contains sulphat of soda, and even sulphat of lime. The presence of these salts may be ascertained by pouring into urine a solution of muriat of barytes, a copious white precipitate appears, consisting of the barytes combined with phosphoric acid, and with sulphuric acid, if any be present. This precipitate must be treated with a sufficient quantity of muriatic acid. The phosphat of barytes is dissolved, but the sulphat of barytes remains unaltered †.

320
[P]utrefaction of u[ri]ne.

No substance putrefies sooner, or exhales a more detestable odour during its spontaneous decomposition, than urine; but there is a very great difference in this respect in different urines. In some, putrefaction takes place almost instantaneously as soon as it is voided; in others, scarcely any change appears for a number of days. Fourcroy and Vauquelin have ascertained that this difference depends on the quantity of gelatine and albumen which urine contains. When there is very little of these substances present, urine remains long unchanged; on the contrary, the greater the quantity of gelatine or albumen, the sooner does putrefaction commence. The putrefaction of urine, therefore, is, in some degree, the test of the health of the person who has voided it; for a superabundance of gelatine in urine always indicates some defect in the power of digestion *.

The rapid putrefaction of urine, then, is owing to the action of gelatine on urea. We have seen already the facility with which that singular substance is decomposed, and that the new products into which it is changed are, ammonia, carbonic acid, and acetous acid. Accordingly, the putrefaction of urine is announced by an ammoniacal smell. Mucilaginous flakes are deposited, consisting of part of the gelatinous matter. The phosphoric acid is saturated with ammonia, and the phosphat of lime, in consequence, is precipitated. Ammonia combines with the phosphat of magnesia, forms with it a triple salt, which crystallizes upon the sides of the vessel in the form of white crystals, composed of six-sided prisms, terminated by six-sided pyramids. The uric and benzoic acids are saturated with ammonia; the acetous acid, and the carbonic acid, which are the products of the decomposition of the urea, are also saturated with ammonia, and notwithstanding the quantity which exhales, the production of this substance is so abundant, that there is a quantity of unsaturated alkali in the liquid. Putrefied urine, therefore, contains chiefly the following substances, most of which are the products of putrefaction:

Ammonia,
Carbonat of ammonia,
Phosphat of ammonia,
Phosphat of magnesia and ammonia,
Urat of ammonia,
Acetite of ammonia,
Benzoat of ammonia,
Muriat of soda,
Muriat of ammonia;

Besides the precipitated gelatine and phosphat of lime *.

The distillation of urine produces almost the same changes; for the heat of boiling water is sufficient to decompose urea, and to convert it into ammonia, carbonic and acetous acids. Accordingly, when urine is distilled, there comes over water, containing ammonia dissolved in it, and carbonat of ammonia in crystals. The acids contained in urine are saturated with ammonia, and the gelatine and phosphat of lime precipitate †.

Such are the properties of the human urine. The urine of other animals has not hitherto been examined with equal care; but it is certain that it differs very considerably from that of men. The urine of cows and horses, and of all ruminating animals, for instance, contains carbonat of lime, without any mixture of phosphat of lime ‡. It contains also a much greater proportion of benzoic acid than that of man.

* [Fo]urcroy [an]d Vauquelin, Ann. Chim. xi. 69.
* Cruikshank, Phil. Mag. ii. [24]1.
† Fourcroy, [A]nn. de [Ch]im. vii. [14]3.
* Ann. de Chim. xxxi.
* Ann. de Chim. xxxi. 70.
† Ibid. 55.
‡ Vauquelin, ibid. xxix. 4.

SECT. XVII. *Of the URINARY CALCULUS.*

Urinary Calculus.

It is well known that concretions not unfrequently form in the bladder, or the other urinary organs, and occasion one of the most dismal diseases to which the human species is liable.

321
Urinary calculi

These concretions were distinguished by the name of *calculi*, from a supposition that they are of a stony nature. They have long attracted the attention of physicians. Chemistry had no sooner made its way into medicine than it began to exercise its ingenuity upon the urinary calculus; and various theories were given of their nature and origin. According to Paracelsus, who gave them the ridiculous name of *duelech*, urinary calculi were intermediate between tartar and stone, and composed of an *animal resin*. Van Helmont pronounced them anomalous coagulations, the offspring of the salts of urine, and of a volatile earthy spirit, produced at once, and destitute of any viscid matter §. Boyle extracted from them, by distillation, oil, and a great quantity of volatile salt. Boerhaave supposed them compounds of oil and volatile salts. Hales extracted from them a prodigious quantity of air. He gave them the name of *animal tartar*, pointed out several circumstances in which they resemble common tartar, and made many experiments to find a solvent of them *. Dr Whytt and Alston pointed out alkalies as solvents of calculi. It was an attempt to discover a more perfect solvent that induced Dr Black to make those experiments which terminated in the discovery of the nature of the alkaline carbonats.

§ De Lithiasi, c. 3.
* Veget. Stat. ii. 189.

322
Analysed by Scheele.

Such was the state of the chemical analysis of calculus, when, in 1776, Scheele published a dissertation on the subject in the *Stockholm Transactions*; which was succeeded by some remarks of Mr Bergman. These

Urinary Calculus.

illustrious chemists completely removed the uncertainty which had hitherto hung over the subject, and ascertained the nature of the calculi which they examined. Since that time considerable additional light has been thrown upon the nature of these concretions by the labours of Austin, Pearson, and, above all, of Fourcroy and Vauquelin, who have lately analysed above 300 calculi, and ascertained the presence of several new substances which had not been suspected. The substances hitherto discovered in urinary calculi are the following:

323 Their component parts.

1. Uric acid,
2. Urat of ammonia,
3. Phosphat of lime (q),
4. Phosphat of magnesia-and-ammonia,
5. Oxalat of lime,
6. Silica,
7. An animal matter.

324 Uric acid.

1. The greater number of calculi consist of uric acid. All those analysed by Scheele were composed of it entirely. Of 300 calculi analysed by Dr Pearson, scarcely one was found which did not contain a considerable quantity of it, and the greater number manifestly were formed chiefly of it. Fourcroy and Vauquelin found it also in the greater number of the 300 calculi which they analysed.

The presence of this acid may easily be ascertained by the following properties: A solution of potass or soda dissolves it readily, and it is precipitated by the weakest acids. The precipitate is soluble in nitric acid, the solution is of a pink colour, and tinges the skin red *.

* *Fourcroy, Ann. de Chim.* xxxii. 216.

325 Urat of ammonia.

2. Urat of ammonia is easily detected by its rapid solubility in fixed alkaline leys, and the odour of ammonia which is perceived during the solution. It is not so often present in urinary calculi as the last mentioned substance. No calculus has hitherto been found composed of it alone, except the very small polygonal calculi, several of which sometimes exist in the bladder together.

It is most usually in thin layers, alternating with some other substance, very easily reduced to powder, and of the colour of ground coffee †.

† *Ibid.* 218.

326 Phosphat of lime.

3. Phosphat of lime is white, without lustre, fiery, friable, stains the hands, paper and cloth. It has very much the appearance of chalk, breaks under the forceps, is insipid, and insoluble in water. It is soluble in nitric, muriatic, and acetous acids, and is again precipitated by ammonia, fixed alkalies, and oxalic acid.

It is never alone in calculi. It is intimately mixed with a gelatinous matter, which remains under the form of a membrane when the earthy part is dissolved by very diluted acids ‡.

‡ *Ibid.*

327 Phosphat of magnesia-and-ammonia.

4. Phosphat of magnesia-and-ammonia occurs in white semitransparent, lameller layers; sometimes it is crystallized on the surface of the calculi in prisms, or what are called *dog-tooth* crystals. It has a weak sweetish taste, it is somewhat soluble in water, and very soluble in acids, though greatly diluted. Fixed alkalies decompose it.

It never forms entire calculi. Sometimes it is mixed with phosphat of lime, and sometimes layers of it cover uric acid or oxalat of lime. It is mixed with the same gelatinous matter as phosphat of lime ‡.

‡ *Fourcroy, Ann de Chim.* xxxii. 219.

328 Oxalat of lime.

5. Oxalat of lime is found in certain calculi, which, from the inequality of their surface, have got the name of *moriform* or *mulberry-shaped* calculi. It is never alone, but combined with a peculiar animal matter, and forming with it a very hard calculus, of a grey colour, difficult to saw asunder, admitting a polish like ivory, exhaling, when sawed, an odour like that of semen. Insoluble and indecomposible by alkalies; soluble in very diluted nitric acid, but slowly, and with difficulty. It may be decomposed by the carbonats of potass and soda. When burnt, it leaves behind a quantity of pure lime, which may be easily recognised by its properties *.

* *Ibid.* 220.

329 Silica.

6. Silica has only been found in two instances by Fourcroy and Vauquelin, though they analysed 300 calculi. No other chemist has observed it. It must therefore be considered as a very uncommon ingredient of these concretions. In the two instances in which it occurred, it was mixed with uric acid and the two phosphats above mentioned †.

† *Ibid.* 221.

330 Animal matters.

7. *Animal matter* appears to compose the cement which binds the different particles of the calculus together, and in all probability it is the cause which influences its formation. It is different in different calculi. Sometimes it has the appearance of gelatine or albumen, at other times it resembles urea. It deserves a more accurate investigation ‡.

‡ *Ibid.*

No general description of the different calculi has hitherto appeared; but Fourcroy and Vauquelin are at present occupied with that subject. They propose to classify them according to their composition; to point out their different species and varieties; to give a method of detecting them by their appearance; to analyse the animal matter by which they are cemented; and to apply all the present chemical knowledge of the subject in the investigation of the cause, the symptoms, and the cure, of that dreadful disease which the urinary calculi produce. As their labour is already very far advanced, it would be unnecessary for us to attempt any classification of calculi. Indeed every attempt of that kind, by any person who has not had an opportunity of analysing a very great number of calculi, must be so exceedingly imperfect as scarcely to be of any use.

We shall satisfy ourselves with the following remarks, deduced almost entirely from the observations which these celebrated chemists have already published.

331 Method of dissolving the calculi.

Many calculi consist entirely, or almost entirely, of uric acid. The animal matter, which serves as a cement to these calculi, appears to be urea. Calculi of this kind may be dissolved by injecting into the bladder solutions of pure potass or soda, so much diluted as not to act upon the bladder itself. The gritty substance, which many persons threatened with the stone discharge along with their urine, which has been called *gravel*, consists almost constantly of uric acid. It may therefore serve as an indication that the subsequent stone, if any such form, is probably composed of uric acid.

The two phosphats, mixed together, sometimes compose calculi. These calculi are very brittle, and generally

(q) Brugnatelli found also phosphat of lime, with excess of acid, in calculi. See *Ann. de Chim.* xxxii. 183.

rally break in pieces during the extraction. Such calculi may be diſſolved by injecting into the bladder muriatic acid, ſo much diluted as ſcarcely to have any taſte of acid.

The phoſphats never form the nucleus of a calculus. They have never been found covered with a layer of uric acid, but they often cover that acid. Hence it would ſeem that the exiſtence of any extraneous matter in the bladder diſpoſes theſe phoſphats to cryſtallize. When extraneous bodies are accidentally introduced into the bladder, and allowed to lodge there, they are conſtantly covered with a coat of phoſphat of ammonia and magneſia, or of the two phoſphats mixed.

As the phoſphat of ammonia and magneſia is not an ingredient of freſh urine, but formed during its putrefaction, when it exiſts in calculi, it would ſeem to indicate a commencement of putrefaction during the time that the urine lodges in the bladder. But putrefaction does not take place ſpeedily in urine, unleſs where there is an exceſs of albumen and gelatine; conſequently we have reaſon to ſuppoſe, that theſe ſubſtances are morbidly abundant in the urine of thoſe patients who are afflicted with calculi conſiſting of the phoſphats: hence alſo we may conclude, that their digeſtion is imperfect. It will no doubt be objected, that dropſical people are not peculiarly ſubject to calculi; but their urine is only morbidly albuminous when the diſeaſe is beginning to diſappear, and then there ſeems to be a deficiency of urea; at leaſt their urine has not been obſerved to putrefy with uncommon rapidity. Beſides, there ſeems to be ſome animal matter preſent, which ſerves as a cement to the phoſphat in all caſes where calculi form.

Urat of ammonia is only found alone in the very ſmall polygonous calculi which exiſt, ſeveral together, in the bladder. In other caſes it is mixed with uric acid. It ſometimes alternates with uric acid or with the phoſphats. It is diſſolved by the ſame ſubſtance that acts as a ſolvent of uric acid.

Oxalat of lime often forms the nucleus of calculi compoſed of layers of uric acid or of the phoſphats. It forms thoſe irregular calculi which are called *moriform*. Theſe calculi are the hardeſt and the moſt difficult of ſolution. A very much diluted nitric acid diſſolves them but very ſlowly. As oxalic acid does not exiſt in urine, ſome morbid change muſt take place in the urine when ſuch calculi are depoſited. Brugnatelli's diſcovery of the inſtantaneous converſion of uric acid into oxalic acid by oxy-muriatic acid, which has been confirmed by the experiments of Fourcroy and Vauquelin, throws conſiderable light upon the formation of oxalic acid in urine, by ſhewing us that uric acid is probably the baſis of it; but in what manner the change is actually produced, it is not ſo eaſy to ſay.

The calculi found in the bladder of other animals have not been examined with the ſame care. Some of them, however, have been ſubjected to an accurate analyſis. No uric acid has ever been found in any of them. Fourcroy found a calculus extracted from the kidney of a horſe compoſed of three parts of carbonat of lime, and one part of phoſphat of lime *. Dr Pearſon examined a urinary calculus of a horſe; it was compoſed of phoſphat of lime and phoſphat of ammonia. Brugnatelli found a calculus extracted from the bladder of a ſow, which was exceedingly hard, compoſed of pure carbonat of lime, including a ſoft nucleus of a fœtid and urinous odour †. Bartholdi examined another calculus of a pig, the ſpecific gravity of which was 1.9300. It conſiſted of phoſphat of lime ‡. Dr Pearſon found a calculus taken from the bladder of a dog compoſed of phoſphat of lime, phoſphat of ammonia, and an animal matter. He found the urinary calculus of a rabbit, of the ſpecific gravity 2, compoſed of carbonat of lime and ſome animal matter ||.

Urinary Calculus.

332
Calculi of inferior animals.

* *Ann. de Chim* xvi. 95.

† *Ibid.* xxxii. 184.

‡ *Ibid.* 185.

|| *Phil. Mag.* ii. 134.

The compoſition of the different animal concretions hitherto examined may be ſeen in the following table.

Horſe.	1. Carbonat of lime and phoſphat of lime *.	* *Fourcroy.*
	2. Phoſph. of lime and phoſph. of ammonia †	† *Pearſon.*
	3. Carbon. of lime and animal matter †.	
Sow.	1. Carbon of lime and an animal nucleus ‡.	‡ *Brugnatelli,*
	2. Phoſphat of lime ¶.	¶ *Bartholdi.*
Dog.	Phoſphat of lime, and of ammonia, and animal matter †.	
Rabbit.	Carbonat of lime and animal matter †.	† *Pearſon.*

We have now given an account of all thoſe ſecretions which have been attentively examined by chemiſts. The remainder have been hitherto neglected; partly owing to the difficulty of procuring them, and partly on account of the multiplicity of other objects which occupied the attention of chemical philoſophers (R). It remains for us now to examine by what proceſſes theſe different ſecretions are formed, how the conſtant waſte of living bodies is repaired, and how the organs themſelves are nouriſhed and preſerved. This ſhall form the ſubject of the following chapter.

Chap. III. Of the Functions of Animals.

The intention of the two laſt chapters was to exhibit a view of the different ſubſtances which enter into the compoſition of animals, as far as the preſent limited ſtate of our knowledge puts it in our power. But were our enquiries concerning animals confined to the mere ingredients of which their bodies are compoſed, even ſuppoſing the analyſis as complete as poſſible, our knowledge of the nature and properties of animals would be imperfect indeed.

How are theſe ſubſtances arranged? How are they produced?

(R) The chief of theſe ſecretions are the following:

1. Cerumen, or ear-wax, is at firſt nearly liquid, and of a whitiſh colour. It gradually acquires conſiſtence. Its taſte is very bitter. Said to be inſoluble in alcohol; but ſoluble in hot water. Does not become rancid by keeping.
2. The humours of the eye.
3. The milky liquor, ſecreted by the thyroid gland.
4. Mucus of the lungs, inteſtinal canal, &c.
5. Smegma of the areola of the breaſts, glans penis, vagina, ſubcutaneous glands, &c.
6. Marrow.

 produced? What purpoſes do they ſerve? What are the diſtinguiſhing properties of animals, and the laws by which they are regulated?

333 Animals reſemble vegetables. Animals reſemble vegetables in the complexneſs of their ſtructure. Like them, they are machines nicely adapted for particular purpoſes, conſtituting one whole, and continually performing an infinite number of the moſt delicate proceſſes. But neither an account of the ſtructure of animals, nor of the properties which diſtinguiſh them from other beings, will be expected here. Theſe have been already treated of ſufficiently in the articles ANATOMY and PHYSIOLOGY *(Encycl.)*, to which we beg leave to refer the reader. We mean only, in the preſent chapter, to take a view of thoſe proceſſes which are concerned in the *production* of animal ſubſtances, which alone properly belong to chemiſtry. The other functions are regulated by laws of a very different nature, which have no reſemblance or analogy to the laws of chemiſtry or mechanics.

334 Require food. 1. Every body knows that animals require food, and that they die ſooner or later if food be withheld from them. There is indeed a very great difference in different animals, with regard to the quantity of food which they require, and the time which they can paſs without it. In general, this difference depends upon the activity of the animal. Thoſe which are moſt active require moſt, and thoſe which move leaſt require leaſt food.

The cauſe of this is alſo well known; the bodies of animals do not remain ſtationary, they are conſtantly waſting; and the waſte is generally proportional to the activity of the animal. It is evident, then, that the body muſt receive, from time to time, new ſupplies, in place of what has been carried off. Hence the uſe of food, which anſwers this purpoſe.

335 Its nature. 2. We are much better acquainted with the food of animals than of vegetables. It conſiſts of almoſt all the animal and vegetable ſubſtances which have been treated of in the former part of this article; for there are but very few of them which ſome animal or other does not uſe as food. Man uſes as food chiefly the muſcles of animals, the ſeeds of certain graſſes, and a variety of vegetable fruits. Almoſt all the inferior animals have particular ſubſtances on which they feed excluſively. Some of them feed on animals, others on vegetables. Man has a greater range; he can feed on a very great number of ſubſtances. To enumerate theſe ſubſtances would be uſeleſs; as we are not able to point out with accuracy what it is which renders one ſubſtance more nouriſhing than another.

Many ſubſtances do not ſerve as nouriſhment at all; and not a few, inſtead of nouriſhing, deſtroy life. Theſe laſt are called *poiſons*. Some poiſons act chemically, by decompoſing the animal body. The action of others is not ſo well underſtood.

336 Converted into chyme. 3. The food is introduced into the body by the mouth, and almoſt all animals reduce it to a kind of pulpy conſiſtence. In man and many other animals this is done in the mouth by means of teeth, and the ſaliva with which it is there mixed; but many other animals grind their food in a different manner. See PHYSIOLOGY, *(Encycl.)* After the food has been thus ground, it is introduced into the ſtomach, where it is ſubjected to new changes. The ſtomach is a ſtrong ſoft bag, of different forms in different animals: in man it has ſome reſemblance to the bag of a *bag-pipe*. In this organ the food is converted into a ſoft pap, which has no reſemblance to the food when firſt introduced. This pap has been called *chyme*. Functions of Animals.

4. Since chyme poſſeſſes new properties, it is evident that the food has undergone ſome changes in the ſtomach, and that the ingredients of which it was compoſed have entered into new combinations. Now, in what manner have theſe changes been produced?

At firſt they were aſcribed to the mechanical action of the ſtomach. The food, it was ſaid, was ſtill farther triturated in that organ; and being long agitated backwards and forwards in it, was at laſt reduced to a pulp. But this opinion, upon examination, was found not to be true. The experiments of Stevens, Reumur, and Spallanzani, demonſtrated, that the formation of chyme is not owing to trituration; for on incloſing different kinds of food in metallic tubes and balls full of holes, in ſuch a manner as to ſcreen them from the mechanical action of the ſtomach, they found, that theſe ſubſtances, after having remained a ſufficient time in the ſtomach, were converted into chyme, juſt as if they had not been incloſed in ſuch tubes. Indeed, the opinion was untenable, even independent of theſe deciſive experiments, the moment it was perceived that chyme differed entirely from the food which had been taken; that is to ſay, that if the ſame food were triturated mechanically out of the body, and reduced to pap of preciſely the ſame conſiſtence with chyme, it would not poſſeſs the ſame properties with chyme; for whenever this fact was known, it could not but be evident that the food had undergone changes in its compoſition.

The change of food into chyme, therefore, was aſcribed by many to *fermentation*. This opinion is indeed very ancient, and it has had many zealous ſupporters among the moderns. When the word *fermentation* was applied to the change produced on the food in the ſtomach, the nature of the proceſs called fermentation was altogether unknown. The appearances, indeed, which take place during that proceſs, had been deſcribed, and the progreſs and the reſult of it were known. Chemiſts had even divided fermentations into different claſſes; but no attempt had been made to explain the cauſe of fermentation, or to trace the changes which take place during its continuance. All that could be meant, then, by ſaying that the converſion of food into chyme in the ſtomach was owing to fermentation, was merely, that the unknown cauſe which acted during the converſion of vegetable ſubſtances into wine or acid, or during their putrefaction, acted alſo during the converſion of the food into chyme, and that the reſult in both caſes was preciſely the ſame. Accordingly, the advocates for this opinion attempted to prove, that air was conſtantly generated in the ſtomach, and that an acid was conſtantly produced: for it was the vinous and acetous fermentations which were aſſigned by the greater number of phyſiologiſts as the cauſe of the formation of chyme. Some indeed attempted to prove, that it was produced by the putrefactive fermentation; but their number was inconſiderable, compared with thoſe who adopted the other opinion.

Our ideas reſpecting fermentation are now ſomewhat more preciſe. It ſignifies a ſlow decompoſition, which takes place when certain animal or vegetable ſubſtances are mixed together at a given temperature; and the

conſequent

Functions of Animals.

consequent production of particular compounds. If therefore the conversion of the food into chyme be owing to fermentation, it is evident that it is totally independent of the stomach any farther than as it supplies temperature; and that the food would be converted into chyme exactly in the same manner, if it were reduced to the same consistence, and placed in the same temperature out of the body. But this is by no means the case; substances are reduced to the state of chyme in a short time in the stomach, which would remain unaltered for weeks in the same temperature out of the body. This is the case with bones; which the experiments of Stevens and Spallanzani have shewn to be soon digested in the stomach of the dog. Further, if the conversion of food into chyme were owing to fermentation, it ought to go on equally well in the stomach and œsophagus. Now, it was observed long ago by Ray and Boyle, that when voracious fish had swallowed animals too large to be contained in the stomach, that part only which was in the stomach was converted into chyme, while what was in the œsophagus remained entire; and this has been fully confirmed by subsequent observations.

Still farther, if the conversion were owing to fermentation, it ought always to take place equally well, provided the temperature be the same, whether the stomach be in a healthy state or not. But it is well known, that this is not the case. The formation of chyme depends very much on the state of the stomach. When that organ is diseased, digestion is constantly ill performed. In these cases, indeed, fermentation sometimes appears, and produces flatulence, acid eructations, &c. which are the well-known symptoms of indegestion. These facts have been long known; they are totally incompatible with the supposition, that the formation of chyme is owing to fermentation. Accordingly that opinion has been for some time abandoned, by all those at least who have taken the trouble to examine the subject.

337 ...e ac... f the ...c

The formation of chyme, then, is owing to the stomach; and it has been concluded, from the experiments of Stevens, Reaumur, Spallanzani, Scopoli, Brugnatelli, Carimini, &c. that its formation is brought about by the action of a particular liquid secreted by the stomach, and for that reason called *gastric juice*.

That it is owing to the action of a liquid, is evident; because if pieces of food be inclosed in close tubes, they pass through the stomach without any farther alteration than would have taken place at the same temperature out of the body: but if the tubes be perforated with small holes, the food is converted into chyme.

This liquid does not act indiscriminately upon all substances: For if grains of corn be put into a perforated tube, and a granivorous bird be made to swallow it, the corn will remain the usual time in the stomach without alteration; whereas if the husk of the grain be previously taken off, the whole of it will be converted into chyme. It is well known, too, that many substances pass unaltered through the intestines of animals, and consequently are not acted upon by the gastric juice. This is the case frequently with grains of oats when they have been swallowed by horses entire with their husks on. This is the case also with the seeds of apples, &c. when swallowed entire by man; yet these very substances, if they have been previously ground sufficiently by the teeth, are digested. It appears, therefore, that it is chiefly the husk or outside of these substances which resists the action of the gastric juice. We see also, that trituration greatly facilitates the conversion of food into chyme.

338 Nature of gastric juice.

The gastric juice is not the same in all animals; for many animals cannot digest the food on which others live. The *conium maculatum* (hemlock), for instance, is a poison to man instead of food, yet the goat often feeds upon it. Many animals, as sheep, live wholly upon vegetables; and if they are made to feed on animals, their stomachs will not digest them: others, again, as the eagle, feed wholly on animal substances, and cannot digest vegetables.

The gastric juice does not continue always of the same nature, even in the same animal: it changes gradually, according to circumstances. Graminivorous animals may be brought to live on animal food; and after they have been accustomed to this for some time, their stomachs become incapable of digesting vegetables. On the other hand, those anamals which naturally digest nothing but animal food may be brought to digest vegetables.

What is the nature of the gastric juice, which possesses these singular properties? It is evidently different in different animals; but it is a very difficult task, if not an impossible one, to obtain it in a state of purity. Various attempts have indeed been made by very ingenious philosophers to procure it; but their analysis of it is sufficient to shew us, that they have never obtained it in a state of purity.

The methods which have been used to procure gastric juice are, *first*, to kill the animal whose gastric juice is to be examined after it has fasted for some time. By this method, Spallanzani collected 37 spoonfuls from the two first stomachs of a sheep. It was of a green colour, undoubtedly owing to the grass which the animal had eaten. He found also half a spoonful in the stomach of some young crows which he killed before they had left their nest.

Small tubes of metal, pierced with holes, and containing a dry sponge, have been swallowed by animals; and when vomited up, the liquid imbibed by the sponge is squezzed out. By this method, Spallanzani collected 481 grains of gastric juice from the stomachs of five crows.

A *third* method consists in exciting vomiting in the morning, when the stomach is without food. Spallanzani tried this method twice upon himself, and collected one of the times 1 oz. 32 gr. of liquid; but the pain was so great, that he did not think proper to try the experiment a third time. Mr Gosse, however, who could excite vomiting whenever he thought proper by swallowing air, has employed that method to collect gastric juice.

Spallanzani has observed, that eagles throw up every morning a quantity of liquid, which he considers as gastric juice; and he has availed himself of this to collect it in considerable quantities.

It is almost unnecessary to remark how imperfect these different methods are, and how far every conclusion drawn from the examination of such juices must deviate from the truth. It is impossible that the gastric juice, obtained by any one of these processes, can be pure; because in the stomach it must be constantly mixed

Functions of Animals

mixed with large quantities of faliva, mucus, bile, food, &c. It may be queftioned, indeed, whether any gaftric juice at all can be obtained by thefe methods: for as the intention of the gaftric juice is to convert the food into chyme, in all probability it is only fecreted, or at leaft thrown into the ftomach when food is prefent.

We need not be furprifed, then, at the contradictory accounts concerning its nature, given us by thofe philofophers who have attempted to examine it; as thefe relate not fo much to the gaftric juice, as to the different fubftances found in the ftomach. The idea that the gaftric juice can be obtained by vomiting, or that it is thrown up fpontaneoufly by fome animals, is, to fay the leaft of it, very far from being probable.

According to Brugnatelli, the gaftric juice of carnivorous animals, as hawks, kites, &c. has an acid and refinous odour, is very bitter, and not at all watery; and is compofed of an uncombined acid, a refin, an animal fubftance, and a fmall quantity of muriat of foda *. The gaftric juice of herbivorous animals, on the contrary, as goats, fheep, &c. is very watery, a little muddy, has a bitter faltifh tafte, and contains ammonia, an animal extract, and a pretty large quantity of muriat of foda †. Mr Carminati found the fame ingredients; but he fuppofes that the ammonia had been formed by the putrefaction of a part of their food, and that in reality the gaftric juice of thefe animals is of an acid nature ‡.

* *Scopoli's Macquer's Dict.*

† *Ibid.*

‡ *Senebier's Obfervat. on Gaftric Juice.*

The accounts which have been given of the gaftric juice of man are fo various, that it is not worth while to tranfcribe them. Sometimes it has been found of an acid nature, at other times not. The experiments of Spallanzani are fufficient to fhew, that this acidity is not owing to the gaftric juice, but to the food. He never found any acidity in the gaftric juice of birds of prey, nor of ferpents, frogs, and fifhes. Crows gave an acidulous gaftric juice only when fed on grain; and he found that the fame obfervation holds with refpect to dogs, herbiferous animals, and domeftic fowls. Carnivorous birds threw up pieces of fhells and coral without alteration; but thefe fubftances were fenfibly diminifhed in the ftomachs of hens, even when inclofed in perforated tubes. Spallanzani himfelf fwallowed calcareous fubftances enclofed in tubes; and when he fed on vegetables and fruits, they were fometimes altered and a little diminifhed in weight, juft as if they had been put into weak vinegar; but when he ufed only animal food, they came out untouched. According to this philofopher, whofe experiments have been by far the moft numerous, the gaftric juice is naturally neither acid nor alkaline. When poured on the carbonat of potafs, it caufes no effervefcence.

Such are the refults of the experiments on the juices taken from the ftomach of animals. No conclufion can be drawn from them refpecting the nature of the gaftric juice. But from the experiments which have been made on the digeftion of the ftomach, efpecially by Spallanzani, the following facts are eftablifhed.

The gaftric juice attacks the furface of bodies, unites to the particles of them which it carries off, and cannot be feparated from them by filtration. It operates with more energy and rapidity the more the food is divided, and its action is increafed by a warm temperature. The food is not merely reduced to very minute parts; its tafte and fmell are quite changed; its fenfible properties are deftroyed, and it acquires new and very different ones. This juice does not act as a ferment; fo far from it, that it is a powerful antifeptic, and even reftores flefh already putrefied. There is not the fmalleft appearance of fuch a procefs; indeed, when the juice is renewed frequently, as in the ftomach, fubftances diffolve in it with a rapidity which excludes all idea of fermentation. Only a few air bubbles make their efcape, which adhere to the alimentary matter, and buoy it up to the top, and which are probably extricated by the heat of the folution.

Functions of Animals

With refpect to the fubftances contained in the ftomach, only two facts have been perfectly afcertained; The firft is, that the juice contained in the ftomach of oxen, calves, fheep, invariably contains uncombined phofphoric acid, as Macquart and Vauquelin have demonftrated: The fecond, that the juice contained in the ftomach, and even the inner coat of the ftomach itfelf, has the property of coagulating milk and the ferum of blood. Dr Young found that feven grains of the inner coat of a calf's ftomach, infufed in water, gave a liquid which coagulated more than 100 ounces of milk; that is to fay, more than 6857 times its own weight; and yet, in all probability, its weight was not much diminifhed.

What the fubftance is which poffeffes this coagulating property, has not yet been afcertained; but it is evidently not very foluble in water; for the infide of a calf's ftomach, after being fteeped in water for fix hours, and then well wafhed with water, ftill furnifhes a liquor on infufion which coagulates milk *: And Dr Young found, that a piece of the inner coat of the ftomach, after being previoufly wafhed with water, and then with a diluted folution of carbonat of potafs, ftill afforded a liquid which coagulated milk and ferum

* *Young.*

It is evident, from thefe facts, that this coagulating fubftance, whatever it is, acts very powerfully; and that it is fcarcely poffible to feparate it completely from the ftomach. But we know at prefent too little of the nature of coagulation to be able to draw any inference from thefe facts. An almoft imperceptible quantity of fome fubftances feems to be fufficient to coagulate milk. For Mr Vaillant mentions in his Travels in Africa, that a porcelain difh which he procured, and which had lain for fome years at the bottom of the fea, poffeffed, in confequence, the property of coagulating milk when put into it; yet it communicated no tafte to the milk, and did not differ in appearance from other cups.

It is probable that the faliva is of fervice in the converfion of food into chyme as well as the gaftric juice. It evidently ferves to dilute the food; and probably it may be ferviceable alfo, by communicating oxygen.

339 Chyme converted into chyle and excrement.

5. The chyme, thus formed, paffes from the ftomach into the inteftines, where it is fubjected to new changes, and at laft converted into two very different fubftances, chyle and excrementitious matter.

6. The *chyle* is a white coloured liquid, very much refembling milk. It is exceedingly difficult to collect it in any confiderable quantity, and for that reafon it has never been accurately analyfed. We know only in general that it refembles milk; containing, like it, an albuminous part capable of being coagulated, a ferum, and globules which have a refemblance to cream †. It contains alfo different falts; and, according to fome, a fubftance fcarcely differing from the fugar of milk. It is probable alfo that it contains iron; but if fo, it muft be

† *Ford on Digeftion,* 121.

Functions of Animals.

be in the ſtate of a white oxide; for an infuſion of nut galls does not alter the colour of chyle ‡.

Fordyce on Digeſtion,

6. Concerning the proceſs by which chyle is formed from chyme, ſcarcely any thing is known. It does not appear that the chyme is preciſely the ſame in all animals; for thoſe which are herbivorous have a greater length of inteſtine than thoſe which are carnivorous. It is certain that the formation of the chyle is brought about by a chemical change, although we cannot ſay preciſely what that change is, or what the agents are by which it is produced. But that the change is chemical, is evident, becauſe the chyle is entirely different, both in its properties and appearance, from the chyme. The chyme, by the action of the inteſtines, is ſeparated into two parts, chyle and excrement: the firſt of which is abſorbed by a number of ſmall veſſels called *lacteals*; the ſecond is puſhed along the inteſtinal canal, and at laſt thrown out of the body altogether.

After the chyme has been converted into chyle and excrement, although theſe two ſubſtances remain mixed together, it does not appear that they are able to decompoſe each other; for perſons have been known ſeldom or never to emit any excrementitious matter *per anum* for years. In theſe, not only the chyle, but the excrementitious matter alſo, was abſorbed by the lacteals; and the excrement was afterwards thrown out of the body by other outlets, particularly by the ſkin: in conſequence of which, thoſe perſons have conſtantly that particular odour about them which diſtinguiſhes excrement. Now in theſe perſons, it is evident that the chyle and excrement, though mixed together, and even abſorbed together, did not act on each other; becauſe theſe perſons have been known to enjoy good health for years, which could not have been the caſe had the chyle been deſtroyed.

340 ... of

7. It has been ſuppoſed by ſome that the decompoſition of the chyme, and the formation of chyle, is produced by the agency of the bile, which is poured out abundantly, and mixed with the chyme, ſoon after its entrance into the inteſtines. If this theory were true, no chyle could be formed whenever any accident prevented the bile from paſſing into the inteſtinal canal; but this is obviouſly not true; for frequent inſtances have occurred of perſons labouring under jaundice from the bile ducts being ſtopped, either by gall-ſtones or ſome other cauſe, ſo completely, that no bile could paſs into the inteſtines; yet theſe perſons have lived for a conſiderable time in that ſtate. Conſequently digeſtion, and therefore the formation of chyle, muſt be poſſible, independent of bile.

The principal uſe of the bile ſeems to be to ſeparate the excrement from the chyle, after both have been formed, and to produce the evacuation of the excrement out of the body. It is probable that theſe ſubſtances would remain mixed together, and that they would perhaps even be partly abſorbed together, were it not for the bile, which ſeems to combine with the excrement, and by this combination to facilitate its ſeparation from the chyle, and thus to prevent its abſorption. It alſo ſtimulates the inteſtinal canal, and cauſes it to evacuate its contents ſooner than it otherwiſe would do; for when there is a deficiency of bile, the body is conſtantly coſtive.

1 ... excrementitious matter.

8. The excrement, then, which is evacuated *per anum*, conſiſts of all that part of the food and chyme which was not converted into chyle, entirely altered however from its original ſtate, partly by the decompoſition which it underwent in the ſtomach and inteſtines, and partly by its combination with bile. Accordingly we find in it many ſubſtances which did not exiſt at all in the food. Thus in the dung of cows and horſes there is found a very conſiderable quantity of benzoic acid. The excrements of animals have not yet been ſubjected to an accurate analyſis, though ſuch an analyſis would throw much light upon the nature of digeſtion. For if we knew accurately the ſubſtances which were taken into the body as food, and all the new ſubſtances which were formed by digeſtion; that is to ſay, the component parts of chyle and of excrement, and the variation which different kinds of food produce in the excrement, it would be a very conſiderable ſtep towards aſcertaining preciſely the changes produced on food by digeſtion, or, which is the ſame thing, towards aſcertaining exactly the phenomena of digeſtion. The only analyſis which has hitherto been made on human excrement is that of Homberg; and as it conſiſted merely in ſubjecting it to diſtillation, it is needleſs to give an account of it. Of late, as Mr Fourcroy informs us, the ſubject has been reſumed in France, and we may ſoon expect ſome very curious and important additions to our knowledge.

342 Excrements of fowls.

Mr Vauquelin has already publiſhed an analyſis of the fixed parts of the excrements of fowls, and a compariſon of them with the fixed parts of the food; from which ſome very curious conſequences may be deduced.

He found that a hen devoured in ten days 11111.843 grains troy of oats. Theſe contained

136.509 gr.	of phoſphat of lime,
219.548	ſilica,
356.057.	

During theſe ten days ſhe layed four eggs; the ſhells of which contained 98.776 gr. phoſphat of lime, and 453.417 gr. carbonat of lime. The excrements emitted during theſe ten days contained 175.529 gr. phoſphat of lime, 58.494 gr. of carbonat of lime, and 185.266 gr. of ſilica. Conſequently the fixed parts thrown out of the ſyſtem during theſe ten days amounted to

	Grains.	
	274.305	phoſphat of lime,
	511.911	carbonat of lime,
	185.266	ſilica,
Given out	971.482	
Taken in	356.057	
	615.425	

Conſequently the quantity of fixed matter given out of the ſyſtem in ten days exceeded the quantity taken in by 615.425 grains.

The ſilica taken in amounted to	219.548 gr.
That given out was only	185.266 gr.
Remains	34.282

Conſequently there diſappeared 34.282 grains of ſilica.

The phoſphat of lime taken in was	136.509 gr.
That given out was	274.305 gr.
	137.796

Conſequently

Functions of Animals.

Conſequently there muſt have been formed, by digeſtion in this fowl, no leſs than 137.796 grains of phoſphat of lime, beſides 511.911 grains of carbonat. Conſequently lime (and perhaps alſo phoſphorus) is not a ſimple ſubſtance, but a compound, and formed of ingredients which exiſt in oat-ſeed, water or air, the only ſuſtance to which the fowl had acceſs. Silica may enter into its compoſition, as a part of the ſilica had diſappeared; but if ſo, it muſt be combined with a great quantity of ſome other ſubſtance *.

These conſequences are too important to be admitted without a very rigorous examination. The experiment muſt be repeated frequently, and we muſt be abſolutely certain that the hen has no acceſs to any calcareous earth, and that ſhe has not diminiſhed in weight; becauſe in that caſe ſome of the calcareous earth, of which part of her body is compoſed, may have been employed. This rigour is the more neceſſary, as it ſeems pretty evident, from experiments made long ago, that *ſome* birds at leaſt, cannot produce eggs unleſs they have acceſs to calcareous earth. Dr Fordyce found, that if the canary bird was not ſupplied with lime at the time of her laying, ſhe frequently died, from her eggs not coming forward properly †. He divided a number of theſe birds at the time of their laying eggs into two parties: to the one he gave a piece of old mortar, which the little animals ſwallowed greedily; they laid their eggs as uſual, and all of them lived: whereas many of the other party, which were ſupplied with no lime, died ‡.

* *Ann. de Chim.* xxix. 16.

† *On Digeſtion*, p. 25.

‡ *Ibid.* p. 26.

[342] Gaſes contained in the inteſtines.

9. The inteſtines ſeldom or never are deſtitute of gaſes, which ſeem to be evolved during the proceſs of digeſtion; and may therefore, in part, be conſidered as excrementitious matter. The only perſon who has examined theſe gaſes with care, is Mr Jurine of Geneva. The reſult of his analyſis is as follows. He found in the ſtomach and inteſtines of a man who had been frozen to death, carbonic acid gas, oxygen gas, hydrogen gas, and azotic gas. The quantity of carbonic acid was greateſt in the ſtomach, and it diminiſhed gradually as the canal receded from the ſtomach; the proportion of oxygen gas was conſiderable in the ſtomach, ſmaller in the ſmall inteſtines, and ſtill ſmaller in the great inteſtines; the hydrogen and azotic gaſes, on the contrary, were leaſt abundant in the ſtomach, more abundant in the ſmall inteſtines, and moſt abundant in the larger inteſtines; the hydrogen gas was moſt abundant in the ſmall inteſtines. It is well known that the flatus diſcharged *per anum* is commonly carbonated hydrogen gas; ſometimes alſo it ſeems to hold ſulphur, or even phoſphorus in ſolution §.

§ *Encyc. Metb. Med.* i. 516.

343 Chyle in the thoracic duct.

10. The chyle, after it has been abſorbed by the lacteals, is carried by them into a pretty large veſſel, known by the name of *thoracic duct*. Into the ſame veſſel likewiſe is diſcharged a tranſparent fluid, conveyed by a ſet of veſſels which ariſe from all the cavities of the body. Theſe veſſels are called *lymphatics*, and the fluid which they convey is called *lymph*. In the thoracic duct, then, the chyle and the lymph are mixed together.

344 Mixed with the lymph,

Very little is known concerning the nature of the *lymph*, as it is ſcarcely poſſible to collect it in any quantity. It is colourleſs, has ſome viſcidity, and is ſaid to be ſpecifically heavier than water. It is ſaid to be coagulable by heat; if ſo, it contains albumen; and, from its appearance, it probably contains gelatine. Its quantity is certainly conſiderable, for the lymphatics are very numerous.

345 And conveyed to the heart and lungs.

11. The chyle and lymph being thus mixed together, are conveyed directly into the blood veſſels. The effect produced by their union in the thoracic duct is not known, but neither the colour nor external properties of the chyle is altered. In man, and many other animals, the thoracic duct enters at the junction of the left ſubclavian and carotid veins, and the chyle is conveyed directly to the heart, mixed with the blood, which already exiſts in the blood veſſels. From the heart, the blood and chyle thus mixed together are propelled into the lungs, where they undergo farther changes.

346 Reſpiration

12. The abſolute neceſſity of *reſpiration*, or of ſomething analogous, is known to every one; and few are ignorant that in man, and hot blooded animals, the organ by which reſpiration is performed is the lungs. For a deſcription of the reſpiratory organs, we refer to the article ANATOMY, *Encycl.* and the reader will find an account of the manner in which that function is performed in the article PHYSIOLOGY, *Encycl.* But what are the changes produced upon the blood and the chyle by reſpiration? What purpoſes does it ſerve to the animal? How comes it to be ſo indiſpenſably neceſſary for its exiſtence? Theſe are queſtions which can only be anſwered by a careful examination of the phenomena of reſpiration.

347 Requires oxygen gas

It has been long known that an animal can only breathe a certain quantity of air for a limited time, after which it becomes the moſt deadly poiſon, and produces ſuffocation as effectually as the moſt noxious gas, or a total abſence of air. It was ſuſpected long ago that this change is owing to the abſorption of a part of the air; and Mayow made a number of very ingenious experiments in order to prove the fact. Dr Prieſtley and Mr Scheele demonſtrated, that the quantity of oxygen gas in atmoſpheric air is diminiſhed; and Lavoiſier demonſtrated, in 1776, that a quantity of carbonic acid gas, which did not previouſly exiſt in it, was found in air after it had been for ſome time reſpired. It was afterwards proved by Lavoiſier, and many other philoſophers, who confirmed and extended his facts, that no animal can live in air totally deſtitute of oxygen. Even fiſh, which do not ſenſibly reſpire, die very ſoon, if the water in which they live be deprived of oxygen gas. Frogs which can ſuſpend their reſpiration at pleaſure, die in about forty minutes, if the water in which they have been confined be covered over with oil *. Inſects and worms, as Vauquelin has proved, exhibit preciſely the ſame phenomena. They require oxygen gas as well as other animals, and die like them if they be deprived of it. They diminiſh the quantity of the oxygen gas in which they live, and give out, by reſpiration, the very ſame products as other animals. Worms, which are more retentive of life than moſt other animals, or at leaſt not ſo much affected by poiſonous gaſes, abſorb every particle of the oxygen gas contained in the air in which they are confined before they die. Mr Vauquelin's experiments were made on the gryllus viridiſſimus, the limax flavus, and helix pomatia †.

* Carrado *Ann. de Chim.* xxi. 171.

† *Ann. de Chim.* xii. 278.

348 Changes produced by it.

The changes which take place during reſpiration are the following:

1. Part of the oxygen gas reſpired diſappears.

2. Carbonic

Functions of Animals.

2. Carbonic acid gas is emitted.

3. Water is emitted in the state of vapour.

The first point is to ascertain exactly the amount of these changes. Though a great many experiments have been made on this subject by different philosophers, the greatest confidence ought to be put in those of Lavoisier, both on account of his uncommon accuracy, and on account of the very complete apparatus which he always employed.

He put a guinea-pig into 708 989 grains troy of oxygen, and after the animal had breathed the gas for an hour, he took it out. He found that the oxygen

gas now amounted only to	592.253 gr.
Consequently there had disappeared	116.736
The carbonic acid gas formed was	130.472
This was composed of about	94.234
oxygen, and	36.238

of carbon. Consequently supposing, as Mr Lavoisier did, that the oxygen absorbed had been employed in the formation of the carbonic acid gas, there still remained to be accounted for 22.502 grains of oxygen which had disappeared. He supposed that this had been employed in the formation of water, a quantity of which had appeared. If so, the water formed must have amounted to 26.429 grains; which was composed of 3.927 hydrogen, the rest oxygen *.

* Ann de Chim. v. 261.

Since the water emitted was not actually ascertained, this experiment can only be considered as an approximation to the truth. Accordingly that very ingenious philosopher contrived an apparatus to ascertain the quantity of oxygen gas absorbed by man, and the quantity of carbonic acid gas and water emitted by him during respiration. This apparatus he had constructed at an expence at least equal to L. 500 sterling. The experiments were completed, and he was preparing them for publication, when, on the 8th of May 1794, he was beheaded by order of Robespierre, after having in vain requested a fortnight's delay to put his papers in order for the press. Thus perished, in the 51st year of his age, the man who, if he had lived a few years longer, promised fair to become the rival of Newton himself. Chemistry, as a science, is deeply indebted to him. He saved it from that confusion into which the thoughtless ardour of many of his contemporaries were plunging it headlong: he arranged and connected and simplified and explained the multitude of insulated facts, which had been accumulating with unexampled celerity; and which, had it not been for his happy arranging genius, might have retarded, instead of advanced, the progress of the science. He reduced all the facts under a few simple heads, and thus made them easily remembered and easily classified. In a few years more, perhaps, he would have traced these general principles to their sources, established the science on the completest induction, and paved for his successors a road as unerring as that which Sir Isaac Newton formed in mechanical philosophy.

Mr Lavoisier's experiments have never been published, but fortunately Mr de la Place has given us the result of them †. He informs us that it was as follows: A man, at an average, consumes, in twenty-four hours, by respiration, 32.48437 ounces troy of oxygen gas; that is to say, that a quantity of oxygen gas, equal to that weight, disappears from the air which he respires in twenty-four hours; that he gives out by respiration, in the same time, 15.73 oz. troy of carbonic acid gas, and 28.55 of water in the state of vapour.

† La Place's Eloge.

Total	44.28	*Oxygen.*
The carbonic acid gas is composed of and 5.243 carbon.		10.486
The water of and 4.2825 hydrogen.		24.2675
Total of the oxygen emitted		34.75416
Total absorbed		32.48437
So that there is		2.2697916

ounces of oxygen emitted more than is absorbed by respiration. Thus it appears that, by respiration, the absolute quantity of oxygen in the blood is diminished.

Dr Menzies found that a man, at a medium, draws in at every respiration 43.77 cubic inches of air, and that $\frac{1}{20}$th of that quantity disappears. Consequently, according to him, at every respiration 2.1885 cubic inches of oxygen gas are consumed. Now 2.1885 cubic inches of that gas amount to 0.68669 gr. troy. Supposing, with Hales, that a man makes 1200 respirations in an hour, the quantity of oxygen gas consumed in an hour will amount to 824.028 grains, and in 24 hours, to 19776.672 grains, or 41.2014 ounces troy. This quantity exceeds that found by Lavoisier considerably; but the allowance of oxygen for every respiration is rather too great. Indeed, from the nature of Dr Menzies's apparatus, it was scarce possible to measure it accurately.

The quantity of water given out by respiration, as determined by Hales, amounts in a day to 20.4 oz. *; but his method was not susceptible of great accuracy. We may therefore, on the whole, consider Lavoisier's determination as by far the nearest to the truth of any that has been given.

* Veget. Stat. ii. 327.

There is, however, a very singular anomaly, which becomes apparent when we compare his experiments on the respiration of the guinea-pig with those on the respiration of man.

The guinea-pig consumed in 24 hours 5.8368 oz. troy of oxygen gas, and emitted 6.5236 oz. of carbonic acid gas. Man, on the other hand, consumes in the same time 32.48437 oz. of oxygen gas, and emits only 15.73 oz. of carbonic acid gas. The oxygen gas consumed by the pig is to the carbonic gas emitted as 1.00 : 1.12; whereas in man it is as 1.000 : 0.484. If we could depend upoon the accuracy of each of these experiments, they would prove, beyond a doubt, that the changes produced by the respiration of the pig are different, at least in degree, from those produced in man; but it is more than probable that some mistake has crept into one or other of the experiments. We have more reason to suspect the first, as it was made before 1778, at a time when a great many circumstances, necessary to insure accuracy, were unknown to Lavoisier.

Such are the substances imbibed and emitted during respiration. It still remains for us to determine what are the changes which it produces on the blood.

It has been long known that the blood which flows in the veins is of a dark reddish purple colour, whereas the arterial blood is of a florid scarlet colour. Lower observed that the colour of the veinous blood was converted into that of arterial during its passage through

Functions of Animals. the lungs. No chyle can be distinguished by its white colour in the blood after it has passed through the lungs. The changes, then, which take place upon the appearance of the blood are two: 1*st*, It acquires a florid red colour; 2*d*, The chyle totally disappears. Now to what are these changes owing?

Lower himself knew that the change was produced by the air, and Mayow attempted to prove that it was by absorbing a part of the air. But it was not till Dr Priestley discovered that veinous blood acquires a scar-

349 Two hypotheses to explain these changes.

let colour when put in contact with oxygen gas, and arterial blood a dark red colour when put in contact with hydrogen gas, or, which is the same thing, that oxygen gas instantly gives veinous blood the colour of arterial; and hydrogen, on the contrary, gives arterial blood the colour of veinous blood: it was not till then that philosophers began to attempt any thing like an explanation of the phenomena of respiration. Two explanations have been given; one or other of which must be true.

The first is, that the oxygen of the air, which disappears, combines with a quantity of carbon and hydrogen given out by the blood in the lungs, and forms with it carbonic acid gas and water in vapour, which are thrown out along with the air expired.

The second is, that the oxygen gas, which disappears, combines with the blood as it passes thro' the lungs; and that, at the instant of this combination, there is set free from the blood a quantity of carbonic acid gas and of water, which are thrown out along with the air expired.

The first of these theories was originally formed by Lavoisier, and it was embraced by La Place, Crawford, Gren, and Girtanner, with a small variation. Indeed it does not differ, except in detail, from the original hypothesis of Dr Priestley, that the use of respiration is to rid the blood of phlogiston; for if we substitute carbon and hydrogen for phlogiston, the two theories precisely agree. Mr Lavoisier attempted not to prove its truth; he only tried to shew that the oxygen absorbed corresponds exactly with the quantity of oxygen contained in the carbonic acid and the water emitted. This coincidence his own experiments have shewn not to hold; consequently the theory is entirely destitute of proof, as far as the proof depends upon this coincidence.

The other hypothesis was proposed by Mr de la Grange, and afterwards supported and illustrated by Mr Hassenfratz.

350 Effects of respiration examined.

In order to discover what the real effects of respiration are, let us endeavour to state accurately the phenomena as far as possible.

In the *first* place, we are certain, from the experiments of Priestley, Girtanner, and Hassenfratz, that when veinous blood is exposed to oxygen gas confined over it, the blood instantly assumes a scarlet colour, and the gas is diminished in bulk; therefore part of the gas has been absorbed. We may consider it as certain, then, that when the colour of veinous blood is changed into arterial, some oxygen gas is absorbed †.

† *Ann. de Chim.* vii. 248.

In the *second* place, no chyle can be discovered in the blood after it has passed through the lungs. Therefore the *white colour* of the chyle at least, is destroyed by respiration, and it assumes a red colour. Now if the red colour of the blood be owing to iron, as many have supposed, this change of colour is a demonstration that oxygen has combined with the iron; for we have seen already, that iron, if it exists in chyle, as it probably does, is in the state of a white oxide. Consequently, when converted into a red oxide, it must absorb oxygen. Even though iron be not the colouring matter of the blood, it would still be probable that the change of colour of the chyle depends on the fixation of oxygen; for Berthollet and Fourcroy have shewn that in several instances substances acquire a red colour by that process.

We may consider it as proved, then, that oxygen enters the blood as it passes through the lungs.

In the *third* place, when arterial blood is put in contact with azotic gas, or carbonic acid gas, it gradually assumes the dark colour of veinous blood, as Dr Priestley found *. The same philosopher also observed that arterial blood acquired the colour of veinous blood when placed in vacuo †. Consequently this alteration of colour is owing to some change which takes place in the blood itself, independent of any external agent.

* *Priestley*, iii. 363.

† *Ibid*, and *Ann. de Chim.* ix. 219.

The arterial blood becomes much more rapidly and deeply dark coloured when it is left in contact with hydrogen gas placed above it ‡. We must suppose therefore that the presence of this gas accelerates and increases the change, which would have taken place upon the blood without any external agent.

‡ *Fourcroy*, *Ann. de Chim.* vii. 149.

If arterial blood be left in contact with oxygen gas, it gradually assumes the same dark colour which it would have acquired in vacuo, or in contact with hydrogen; and after this change oxygen can no longer restore its scarlet colour §. Therefore it is only upon a part of the blood that the oxygen acts; and after this part has undergone the change which occasions the dark colour, the blood loses the power of being affected by oxygen.

§ *Ibid.* ix. 268.

Mr Hassenfratz poured into veinous blood a quantity of oxy-muriatic acid; the blood was instantly decomposed, and assumed a deep and almost black colour. When he poured common muriatic acid into blood, the colour was not altered ‖. Now oxy-muriatic acid has the property of giving out its oxygen readily; consequently the black colour was owing to the instant combination of a part of the blood with oxygen.

‖ *Ibid.*

The facts therefore lead us to conclude, with La Grange and Hassenfratz, that during respiration the oxygen, which disappears, enters the blood; that during the circulation this oxygen combines with a certain part of the blood; and that the veinous colour is owing to this new combination. We must conclude, too, that the substance which causes this dark colour leaves the blood during its circulation thro' the lungs, otherwise it could not be capable of assuming the florid colour. Now we know what the substances are which are emitted during respiration; they are water and carbonic acid gas. It must be to the gradual combination of oxygen, then, during the circulation, with hydrogen and carbon, that the colour of veinous blood is owing. And since the same combination takes place every time that the blood passes through the lungs, we must conclude, that it is only a part of the hydrogen and carbon which is acted upon each time. Let us now attempt, with these data, to form some notion of the decomposition which goes on during the circulation of the blood.

351 Contributes to the formation of blood.

It is probable that, during a considerable part of the day, there is a constant influx of chyle into the blood; and we are certain that lymph is constantly flowing into to it. Now it appears, from the most accurate observations hitherto made, that neither chyle nor lymph contain fibrina, which forms a very conspicuous part of the blood. This fibrina is employed to supply the waste of the muscles, the most active parts of the body, and therefore, in all probability, requiring the most frequent supply. Nor can it be doubted that it is employed for other useful purposes. The quantity of fibrina in the blood, then, must be constantly diminishing, and therefore new fibrina must be constantly formed. But the only substances out of which it can be formed are the chyle and lymph, neither of which contain it. There must therefore be a continual decomposition of the chyle and lymph going on in the blood-vessels, and a continual new formation of fibrina. Other substances also may be formed; but we are certain that this *must* be formed there, because it does not exist previously. Now, one great end of respiration must undoubtedly be to assist this decomposition of chyle and complete formation of blood.

It follows, from the experiments of Fourcroy formerly enumerated, that fibrina contains more azot, and less hydrogen and carbon, than any of the other ingredients of the blood, and consequently also than any of the ingredients of the chyle. In what manner the chyle, or a part of it, is converted into fibrina, it is impossible to say: we are not sufficiently acquainted with the subject to be able to explain the process. But we can see at least, that carbon and hydrogen must be abstracted from that part of the chyle which is to be converted into fibrina: And we know, that these substances are actually thrown out by respiration. We may conclude, then, that *one* use of the oxygen absorbed is, to abstract a quantity of carbon and hydrogen from a part of the chyle by compound affinity, in such proportions, that the remainder becomes fibrina; therefore one end of respiration is to form fibrina. Doubtless the other ingredients of the blood are also new modified, though we know too little of the subject to throw any light upon it.

352 Produces animal heat;

13. But the complete formation of blood is not the only advantage gained by respiration: the *temperature* of all animals depends upon it. It has been long known, that those animals which do not breathe have a temperature but very little superior to the medium in which they live. This is the case with fishes and many insects. Man, on the contrary, and quadrupeds which breathe, have a temperature considerably higher than the atmosphere: that of man is 98°. Birds, who breathe in proportion a still greater quantity of air than man, have a temperature equal to 103° or 104°. It has been proved, that the temperature of all animals is proportional to the quantity of air which they breathe in a given time.

These facts are sufficient to demonstrate, that the heat of animals depends upon respiration. But it was not till Dr Black's doctrine of latent heat became known to the world, that any explanation of the cause of the temperature of breathing animals was attempted. That illustrious philosopher, whose discoveries form the basis upon which all the scientific part of chemistry has been reared, saw at once the light which his doctrine of latent heat threw upon this part of physiology, and he applied it very early to explain the temperature of animals.

According to him, part of the latent heat of the air inspired becomes sensible; and of course, the temperature of the lungs, and the blood that passes through them, must be raised; and the blood, thus heated, communicates its heat to the whole body. This opinion was ingenious, but it was liable to an unanswerable objection: for if it were true, the temperature of the body ought to be greatest in the lungs, and to diminish gradually as the distance from the lungs increases; which is not true. The theory, in consequence, was abandoned even by Dr Black himself; at least he made no attempt to support it.

Lavoisier and Crawford, who considered all the changes operated by respiration as taking place in the lungs, accounted for the origin of the animal heat almost precisely in the same manner with Dr Black. According to them, the oxygen gas of the air combines in the lungs with the hydrogen and carbon emitted by the blood. During this combination, the oxygen gives out a great quantity of caloric, with which it had been combined; and this caloric is not only sufficient to support the temperature of the body, but also to carry off the new formed water in the state of vapour, and to raise considerably the temperature of the air inspired. According to these philosophers, then, the whole of the caloric which supports the temperature of the body is evolved in the lungs. Their theory accordingly was liable to the same objection with Dr Black's; but they obviated it in the following manner: Dr Crawford found, that the specific caloric of arterial blood was 1.0300, while that of veinous blood was only 0.8928. Hence he concluded, that the instant veinous blood is changed into arterial blood, its specific caloric increases; consequently it requires an additional quantity of caloric to keep its temperature as high as it had been while veinous blood. This addition is so great, that the whole new caloric evolved is employed: therefore the temperature of the lungs must necessarily remain the same as that of the rest of the body. During the circulation, arterial blood is gradually converted into veinous; consequently its specific caloric diminishes, and it must give out heat. This is the reason that the temperature of the extreme parts of the body does not diminish.

This explanation is certainly ingenious; but it is not quite satisfactory; for the difference in the specific caloric, granting it to be accurate, is too small to account for the great quantity of heat which must be evolved. It is evident that it must fall to the ground altogether, provided, as we have seen reason to suppose, the carbonic acid gas and water be not formed in the lungs, but during the circulation.

Since the oxygen enters the blood, and combines with it in the state of gas, it is evident that it will only part at first with some of its caloric; and this portion is chiefly employed in carrying off the carbonic acid gas and the water. For the reason that the carbonic acid leaves the blood at the instant that the oxygen gas enters it, seems to be this: The oxygen gas combines with the blood, and part of its caloric unites at the same instant to the carbonic acid, and converts it into gas: another portion converts the water into vapour. The rest of the caloric is evolved during the circulation when the oxygen combines with hydrogen and carbon, and forms water and carbonic acid gas. The quantity of caloric evolved in the lungs seems not only sufficient to carry off the carbonic acid and water, which the diminution

...ution of the ſpecific caloric (if it really take place) muſt facilitate; but it ſeems alſo to raiſe the temperature of the blood a little higher than it was before. For Mr John Hunter conſtantly found, that the heat of the heart in animals was a degree higher than any other part of the body which he examined. Now this could ſcarcely happen unleſs the temperature of the blood were ſomewhat raiſed during reſpiration.

353 And ſupports the circulation.

Thus we have ſeen two uſes which reſpiration ſeems to ſerve. The firſt is the completion of blood by the formation of fibrina; the ſecond is the maintaining of the temperature of the body at a particular ſtandard, notwithſtanding the heat which it is continually giving out to the colder ſurrounding bodies. But there is a third purpoſe, which explains why the animal is killed ſo ſuddenly when reſpiration is ſtopped. The circulation of the blood is abſolutely neceſſary for the continuance of life. Now the blood is circulated in a great meaſure by the alternate contractions of the heart. It is neceſſary that the heart ſhould contract regularly, otherwiſe the circulation could not go on. But the heart is ſtimulated to contract by the blood: and unleſs blood be made to undergo the change produced by reſpiration, it ceaſes almoſt inſtantaneouſly to ſtimulate. As the blood receives oxygen in the lungs, we may conclude that the preſence of oxygen is neceſſary to its ſtimulating power *.

* *Girtanner, Jour. de Phyſ.* xxxix.

354 Kidneys employed in the formation of blood.

14. Thus we have reaſon to ſuppoſe, that chyle and lymph are converted into blood during the circulation; and that the oxygen gas ſupplied by reſpiration is one of the principal agents in this change. But beſides the lungs and arteries, there is another organ, the ſole uſe of which is alſo to produce ſome change or other in the blood, which renders it more complete, and more proper for the various purpoſes to which it is applied. This organ is the *kidney*.

For the ſtructure of the kidneys, which in man and quadrupeds are two in number, we refer to ANATOMY, *Encycl.* A very great proportion of blood paſſes thro' them; indeed, we have every reaſon to conclude, that the whole of the blood paſſes through them very frequently.

Theſe organs ſeparate the urine from the blood, to be afterwards evacuated without being applied to any purpoſe uſeful to the animal.

The kidneys are abſolutely neceſſary for the continuance of the life of the animal; for it dies very ſpeedily when they become by diſeaſe unfit to perform their functions: therefore the change which they produce in the blood is a change neceſſary for qualifying it to anſwer the purpoſes for which it is intended.

As the urine is immediately excreted, it is evident that the change which the kidneys perform is intended ſolely for the ſake of the blood. It is not merely the abſtraction of a quantity of water and of ſalts, accumulated in the blood, which the kidney performs. A chemical change is certainly produced, either upon the whole blood, or at leaſt on ſome important part of it; for there are two ſubſtances found in the urine which do not exiſt in the blood. Theſe two ſubſtances are urea and uric acid. They are formed, therefore, in the kidneys; and as they are thrown out, after being formed, without being applied to any uſeful purpoſe, they are certainly not formed in the kidneys for their own ſake. Some part of the blood, then, muſt be decompoſed in the kidney, and a new ſubſtance, or new ſubſtances, muſt be formed; and the urea and uric acid muſt be formed at the ſame time, in conſequence of the combined action of the affinities which produce the change on the blood; and being uſeleſs, they are thrown out, together with a quantity of water and ſalts, which, in all probability, were uſeful in bringing about the changes which take place in the arteries and in the kidneys, but which are no longer of any ſervice after theſe changes are brought about.

The changes operated upon the blood in the kidneys are hitherto altogether unknown; but they muſt be important.

355 Cutaneous veſſels

Provided the method of analyſing animal ſubſtances were ſo far perfected as to admit of accurate concluſions, conſiderable light might be thrown upon this ſubject, by analyſing with care a portion of blood from the emulgent vein and artery ſeparately, and aſcertaining preciſely in what particulars they differ from each other.

15. Thus we have ſeen that the principal changes which the blood undergoes, as far at leaſt as we are at preſent acquainted with them, take place in the lungs, in the kidneys, and in the arteries. In the lungs, a quantity of water and carbonic acid gas is emitted from the blood, and in the kidney the urine is formed and ſeparated from it. There ſeems alſo to be ſomething thrown out from the blood during its circulation in the arteries, at leaſt through thoſe veſſels which are near the ſurface of the body: For it is a fact, that certain ſubſtances are conſtantly emitted from the ſkins of animals. Theſe ſubſtances are known in general by the name of *perſpirable matter* or *perſpiration*. They have a great reſemblance to what is emitted in the lungs; which renders it probable, that they are both owing to the ſame cauſe; namely, to the decompoſition produced in the blood by the effects of reſpiration. They conſiſt chiefly of water in a ſtate of vapour, carbon, and oil.

356 Emit aqueous vapour

The quantity of aqueous vapour differs very conſiderably, according to circumſtances. It has been ſhewn to be greateſt in hot weather, and in hot climates, and after great exerciſe; and its relation to the quantity of urine has been long known. When the aqueous vapour perſpired is great, the quantity of urine is ſmall, and *vice verſa*.

The moſt accurate experiments on this matter that we have ſeen are thoſe of Mr Cruikſhank. He put his hand into a glaſs veſſel, and luted its mouth at his wriſt by means of a bladder. The interior ſurface of the veſſel became gradually dim, and drops of water trickled down. By keeping his hand in this manner for an hour, he collected 30 grains of a liquid, which poſſeſſed all the properties of pure water *. On repeating the ſame experiment at nine in the evening (thermometer 62°), he collected only 12 grains. The mean of theſe is 21 grains. But as the hand is more expoſed than the trunk of the body, it is reaſonable to ſuppoſe that the perſpiration from it is greater than that from the hand. Let us therefore take 30 grains per hour as the mean; and let us ſuppoſe, with Mr Cruikſhank, that the hand is $\frac{1}{60}$th of the ſurface of the body. The perſpiration in an hour would amount to 1800 grains, and in 24 hours to 43200 grains, or 7 pounds 6 ounces troy.

* *On Inſenſible Perſpiration*, p.

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unctions of Animals.

He repeated the experiment again after hard exerciſe, and collected in an hour 48 grains of water *. He found alſo, that this aqueous vapour pervaded his ſtocking without difficulty; and that it made its way thro' a ſhamoy leather glove, and even through a leather boot, though in much ſmaller quantity than when the leg wanted that covering †.

On Inſen-
ſible Perſpi-
ration,
70.
Ibid. p.

It is not difficult to ſee why the quantity of watery vapour diminiſhes with cold. When the ſurface of the body is expoſed to a cold temperature, the capacity of the cutaneous veſſels diminiſhes, and conſequently the quantity which flows through them muſt decreaſe.

When the temperature, on the other hand, is much increaſed, either by being expoſed to a hot atmoſphere, or by violent exerciſe, the perſpired vapour not only increaſes in quantity, but even appears in a liquid form. This is known by the name of *ſweat*. In what manner ſweat is produced, is not at preſent known; but we can ſee a very important ſervice which it performs to the animal.

No ſooner is it thrown upon the ſurface of the ſkin than it begins to evaporate. But the change into vapour requires heat; accordingly a quantity of heat is abſorbed, and the temperature of the animal is lowered. This is the reaſon that animals can endure to remain for ſome time in a much higher temperature without injury than could have been ſuppoſed.

The experiments of Tillet, and the ſtill more deciſive experiments of Fordyce and his aſſociates, are well known. Theſe gentlemen remained a conſiderable time in a temperature exceeding the boiling point of water.

357
Carbon,

Beſides water, it cannot be doubted that *carbon* is alſo emitted from the ſkin; but in what ſtate, the experiments hitherto made do not enable us to decide. Mr Cruikſhank found, that the air of the glaſs veſſel in which his hand and foot had been confined for an hour, contained carbonic acid gas; for a candle burned dimly in it, and it rendered lime-water turbid *. And Mr Jurine found, that air which had remained for ſome time in contact with the ſkin, conſiſted almoſt entirely of carbonic acid gas †. The ſame concluſion may be drawn from the experiments of Ingenhouſz and Milly ‡.

Ibid. p.
and 81.
nc. Meth.
d. i. p.
id. p.

Now it is evident, that the carbonic acid gas which appeared during Mr Cruikſhank's experiment, did not previouſly exiſt in the glaſs veſſel; conſequently it muſt have either been tranſmitted ready formed through the ſkin, or formed during the experiment by the abſorption of oxygen gas, and the conſequent emiſſion of carbonic acid gas. The experiments of Mr Jurine do not allow us to ſuppoſe the firſt of theſe to be true; for he found, that the quantity of air allowed to remain in contact with the ſkin did not increaſe. Conſequently the appearance of the carbonic acid gas muſt be owing, either to the emiſſion of carbon, which forms carbonic acid gas by combining with the oxygen gas of the air, or to the abſorption of oxygen gas, and the ſubſequent emiſſion of carbonic acid gas; preciſely in the ſame manner, and for the ſame reaſon, that theſe ſubſtances are emitted by the lungs. The laſt is the more probable opinion; but the experiments hitherto made do not enable us to decide.

358
l an oily
ter.

Beſides water and carbon, or carbonic acid gas, the ſkin emits alſo a particular odorous ſubſtance. That every animal has a peculiar ſmell, is well known: the dog can diſcover his maſter, and even trace him to a diſtance by the ſcent. A dog, chained ſome hours after his maſter had ſet out on a journey of ſome hundred miles, followed his footſteps by the ſmell, and found him on the third day in the midſt of a crowd *. But it is needleſs to multiply inſtances of this fact, they are too well known to every one. Now this ſmell muſt be owing to ſome peculiar matter which is conſtantly emitted; and this matter muſt differ ſomewhat either in quantity or ſome other property, as we ſee that the dog eaſily diſtinguiſhes the individual by means of it. Mr Cruikſhank has made it probable that this matter is an oily ſubſtance; or at leaſt that there is an oily ſubſtance emitted by the ſkin. He wore repeatedly, night and day for a month, the ſame veſt of fleecy hoſiery during the hotteſt part of the ſummer. At the end of this time he always found an oily ſubſtance accumulated in conſiderable maſſes on the nap of the inner ſurface of the veſt, in the form of black tears. When rubbed on paper, it makes it tranſparent, and hardens on it like greaſe. It burns with a white flame, and leaves behind it a charry reſiduum †.

* Cruikſhank, ibid. p. 93.

† Ibid. p. 92.

It has been ſuppoſed that the ſkin has the property of *abſorbing moiſture* from the air; but this opinion has not been confirmed by experiments, but rather the contrary.

359
Whether the ſkin abſorbs moiſture,

The chief arguments in favour of the abſorption of the ſkin, have been drawn from the quantity of moiſture diſcharged by urine being, in ſome caſes, not only greater than the whole drink of the patient, but even than the whole of his drink and food. But it ought to be remembered that, in diabetes, the diſeaſe here alluded to, the weight of the body is continually diminiſhing, and therefore part of it muſt be conſtantly thrown off. Beſides, it is ſcarcely poſſible in that diſeaſe to get an accurate account of the food ſwallowed by the patients; and in thoſe caſes where very accurate accounts have been kept, and where deception was not ſo much practiſed, the urine was found not to exceed the quantity of drink *. In a caſe of diabetes, related with much accuracy by Dr Gerard, the patient was bathed regularly during the early part of the diſeaſe in warm water, and afterwards in cold water: he was weighed before and after bathing, and no ſenſible difference was ever found in his weight †. Conſequently, in that caſe, the quantity abſorbed, if any, muſt have been very ſmall.

* See Reil's on Diabetes.

† Ibid. ii. 73.

It is well known, that thirſt is much alleviated by cold bathing. By this plan, Captain Bligh kept his men cool and in good health during their very extraordinary voyage acroſs the South Sea. This has been conſidered as owing to the abſorption of water by the ſkin. But Dr Currie had a patient who was waſting faſt for want of nouriſhment, a tumor in the œſophagus preventing the poſſibility of taking food, and whoſe thirſt was always alleviated by bathing; yet no ſenſible increaſe of weight, but rather the contrary, was perceived after bathing. It does not appear, then, that in either of theſe caſes water was abſorbed.

Farther, Seguin has ſhewn that the ſkin does not abſorb water during bathing, by a ſtill more complete experiment: He diſſolved ſome mercurial ſalt in water, and found that the mercury produced no effect upon a perſon that bathed in the water, provided no part of the

Functions of Animals.

the cuticle was injured; but upon rubbing off a portion of the cuticle, the mercurial solution was absorbed, and the effects of the mercury became evident upon the body. Hence it follows irresistibly, that water, at least in the state of *water*, is not absorbed by the skin when the body is plunged into it, unless the cuticle be first removed.

360 Or any other substance.

This may perhaps be considered as a complete proof that no such thing as absorption is performed by the skin; and that therefore the appearance of carbonic acid gas, which takes place when air is confined around the skin, must be owing to the emission of carbon. But it ought to be considered, that although the skin cannot absorb water, this is no proof that it cannot absorb other substances; particularly, that it cannot absorb oxygen gas, which is very different from water. It is well known, that water will not pass through bladders, at least for some time; yet Dr Priestly found that veinous blood acquired the colour of arterial blood from oxygen gas, as readily when these substances were separated by a bladder as when they were in actual contact. He found, too, that when gases were confined in bladders, they gradually lost their properties. It is clear from these facts, that oxygen gas can pervade bladders; and if it can pervade them, why may it not also pervade the cuticle? Nay, farther, we know from the experiments of Cruikshank, that the vapour perspired passes through leather, even when prepared so as to keep out moisture, at least for a certain time. It is possible, then, that water, when in the state of vapour, or when dissolved in air, may be absorbed, although water, while in the state of water, may be incapable of pervading the cuticle. The experiments, then, which have hitherto at least been made upon the absorption of the skin, are altogether insufficient to prove that air and vapour cannot pervade the cuticle; provided at least there be any facts to render the contrary supposition probable.

Now that there are such facts cannot be denied. We shall not indeed produce the experiment of Van Mons as a fact of that kind, because it is liable to objections, and at best is very undecisive. Having a patient under his care who, from a wound in the throat, was incapable for several days of taking any nourishment, he kept him alive during that time, by applying to the skin in different parts of the body, several times a day, a sponge dipt in wine or strong soup *. A fact mentioned by Dr Watson is much more important, and much more decisive. A lad at Newmarket, who had been almost starved in order to bring him down to such a weight as would qualify him for running a horse race, was weighed in the morning of the race day; he was weighed again just before the race began, and was found to have gained 30 ounces of weight since the morning: yet in the interval he had only taken a single glass of wine. Here absorption must have taken place, either by the skin, or lungs, or both. The difficulties in either case are the same; and whatever renders absorption by one probable, will equally strengthen the probability that absorption takes place by the other (R).

* Phil. Mag. vi. 95.

16. We have now seen the process of digestion, and the formation of blood, as far at least as we are acquainted with it. But to what purposes is this blood employed, which is formed with so much care, and for the formation of which so great an apparatus has been provided? It answers two purposes. The parts of which the body is composed, bones, muscles, ligaments, membranes, &c. are continually changing. In youth, they are increasing in size and strength, and in mature age they are continually acting, and consequently continually liable to waste and decay. They are often exposed to accidents, which render them unfit for performing their various functions; and even when no such accident happens, it seems necessary for the health of the system that they should be every now and then renewed. Materials therefore must be provided for repairing, increasing, or renewing all the various organs of the body. Phosphat of lime and gelatine for the bones, fibrina for the muscles, albumen for the cartilages and membranes, &c. Accordingly all these substances are laid up in the blood; and they are drawn from that fluid as from a storehouse whenever they are required. The process by which the different parts of the blood are made part of the various organs of the body is called *assimilation*.

361 Blood supplies the waste of the system.

362 Assimilation.

Over the nature of assimilation the thickest darkness still hangs; there is no key to explain it, nothing to lead us to the knowledge of the instruments employed. Facts, however, have been accumulated in sufficient numbers to put the existence of the process beyond the reach of doubt. The healing, indeed, of every fractured bone, and every wound of the body, is a proof of its existence, and an instance of its action.

363 Every assimilating organ produces a peculiar change,

Every organ employed in assimilation has a peculiar office; and it always performs this office whenever it has materials to act upon, even when the performance of it is contrary to the interest of the animal. Thus the stomach always converts food into chyme, even when the food is of such a nature that the process of digestion will be retarded rather than promoted by the change. If warm milk, for instance, or warm blood, be thrown into the stomach, they are always decomposed by that organ, and converted into chyme; yet these substances are much more nearly assimilated to the animal before the action of the stomach than after it. The same thing happens when we eat animal food.

364 And no other change.

On the other hand, a substance introduced into an organ employed in assimilation, if it has undergone precisely the change which that organ is fitted to produce, is not acted upon by that organ, but passed on unaltered to the next assimilating organ. Thus it is the office of the intestines to convert chyme into chyle. Accordingly, whenever chyme is introduced into the intestines, they perform their office, and produce the usual change; but if chyle itself be introduced into the intestines, it is absorbed by the lacteals without alteration. The experiment, indeed, has not been tried with true chyle, because it is scarce possible to procure it in sufficient quantity; but when milk, which resembles chyle pretty accurately, is thrown into the jejunum, it is absorbed unchanged by the lacteals *.

* Fordyce Digestion, 189.

Again,

(R) The Abbé Fontana also found, after walking in moist air for an hour or two, he returned home some ounces heavier than he went out, notwithstanding he had suffered considerable evacuation from a brisk purge purposely taken for the experiment. This increase, indeed, might be partly accounted for by the absorption of moisture by his clothes.

Functions of Animals.

Again, the office of the blood veſſels, as aſſimilating organs, is to convert chyle into blood. Chyle, accordingly, cannot be introduced into the arteries without undergoing that change; but *blood* may be introduced from another animal without any injury, and conſequently without undergoing any change. This experiment was firſt made by Lower, and it has ſince been very often repeated.

Alſo, if a piece of freſh muſcular fleſh be applied to the muſcle of an animal, they adhere and incorporate without any change, as has been ſufficiently eſtabliſhed by the experiments of Mr J. Hunter. And Buvina has aſcertained, that freſh bone may, in the ſame manner, be engrafted on the bones of animals of the ſame or of different ſpecies †.

† Phil. Mag. vi. 98.

In ſhort, it ſeems to hold, at leaſt as far as experiments have hitherto been made, that foreign ſubſtances may be incorporated with thoſe of the body, provided they be preciſely of the ſame kind with thoſe to which they are added, whether fluid or ſolid. Thus chyle may be mixed with chyle, blood with blood, muſcle with muſcle, and bone with bone. The experiment has not been extended to the other animal ſubſtances, the nerves, for inſtance; but it is extremely probable that it would hold with reſpect to them alſo.

On the other hand, when ſubſtances are introduced into any part of the body which are not the ſame with that part, nor the ſame with the ſubſtance upon which that part acts; provided they cannot be thrown out readily, they deſtroy the part, and perhaps even the animal. Thus foreign ſubſtances introduced into the blood very ſoon prove fatal; and introduced into wounds of the fleſh or bones, they prevent theſe parts from healing.

365 Their power limited.

Although the different aſſimilating organs have the power of changing certain ſubſtances into others, and of throwing out the uſeleſs ingredients, yet this power is not abſolute, even when the ſubſtances on which they act are proper for undergoing the change which the organs produce. Thus the ſtomach converts food into chyme, the inteſtines chyme into chyle, and the ſubſtances which have not been converted into chyle are thrown out of the body. If there happen to be preſent in the ſtomach and inteſtines any ſubſtance which, though incapable of undergoing the changes, at leaſt, by the action of the ſtomach and inteſtines, yet has a ſtrong affinity, either for the whole chyme and chyle, or for ſome particular part of it, and no affinity for the ſubſtances which are thrown out, that ſubſtance paſſes along with the chyle, and in many caſes continues to remain chemically combined with the ſubſtance to which it is united in the ſtomach, even after that ſubſtance has been completely aſſimilated, and made a part of the body of the animal. Thus there is a ſtrong affinity between the colouring matter of madder and phoſphat of lime. Accordingly, when madder is taken into the ſtomach, it combines with the phoſphat of lime of the food, paſſes with it through the lacteals and blood veſſels, and is depoſited with it in the bones, as was proved by the experiments of Duhamel. In the ſame manner muſk, indigo, &c. when taken into the ſtomach, make their way into many of the ſecretions.

Theſe facts ſhew us, that aſſimilation is a chemical proceſs from beginning to end; that all the changes are produced according to the laws of chemiſtry; and that we can even derange the regularity of the proceſs by introducing ſubſtances whoſe mutual affinities are too ſtrong for the organs to overcome.

366 Aſſimilation a chemical proceſs;

It cannot be denied, then, that the aſſimilation of food conſiſts merely in a certain number of chemical decompoſitions which that food undergoes, and the conſequent formation of certain new compounds. But are the *agents* employed in aſſimilation merely chemical agents? We cannot produce any thing like theſe changes on the food out of the body, and therefore we muſt allow that they are the conſequence of the action of the animal organs. But this action, it may be ſaid, is merely the ſecretion of particular juices, which have the property of inducing the wiſhed-for change upon the food; and this very change would be produced out of the body, provided we could procure theſe ſubſtances, and apply them in proper quantity to the food. If this ſuppoſition be true, the ſpecific action of the veſſels conſiſts in the ſecretion of certain ſubſtances; conſequently the cauſe of this ſecretion is the *real* agent in aſſimilation. Now, can the cauſe of this ſecretion be ſhewn to be merely a chemical agent? Certainly not. For in the ſtomach, where only this ſecretion can be ſhewn to exiſt, it is not always the ſame, but varies according to circumſtances. Thus eagles at firſt cannot digeſt grain, but they may be brought to do it by perſiſting in making them uſe it as food. On the contrary, a lamb cannot at firſt digeſt animal food, but habit will alſo give it this power. In this caſe, it is evident that the gaſtric juice changes according to circumſtances. Now this is ſo far from being a caſe of a chemical law, that it is abſolutely incompatible with every ſuch law. The agent in aſſimilation, then, is not a chemical agent, but one which acts upon different principles. It is true, indeed, that every ſtep in the proceſs is chemical; but the agent which regulates theſe chemical proceſſes, which prevents them from acting, except in particular circumſtances and on particular ſubſtances, and modifies this action according to circumſtances, is not a mere chemical agent, but endowed with very different properties.

367 But the agent not chemical.

The preſence and power of this agent will be ſtill more evident, if we conſider the immunity of the ſtomach of the living animal during the proceſs of digeſtion. The ſtomach of animals is as fit for food as any other ſubſtance. The gaſtric juice, therefore, muſt have the ſame power of acting on it, and of decompoſing it, that it has of acting on other ſubſtances; yet it is well known that the ſtomach is not affected by digeſtion while the animal retains life; though, as Mr Hunter aſcertained, the very gaſtric juice which the living ſtomach ſecretes often diſſolves the ſtomach itſelf after death. Now what is the power which prevents the gaſtric juice from acting on the ſtomach during life? Certainly neither a chemical nor mechanical agent, for theſe agents muſt ſtill retain the ſame power after death. We muſt, then, of neceſſity conclude, that there exiſts in the animal an agent very different from chemical and mechanical powers, ſince it controuls theſe powers according to its pleaſure. Theſe powers therefore in the living body are merely the ſervants of this ſuperior agent, which directs them ſo as to accompliſh always one particular end. This agent ſeems to regulate the chemical powers, chiefly by bringing only certain ſubſtances together which are to be decompoſed, and by keeping at a diſtance thoſe ſubſtances which would interfere with, or diminiſh, or ſpoil the product, or injure

Functions of Animals.

injure the organ. And we fee that this feparation is always attended to even when the fubftances are apparently mixed together. For the very fame products are not obtained which would be obtained by mixing the fame fubftances together out of the body that are produced by mixing them in the body; confequently all the fubftances are not left at full liberty to obey the laws of their mutual affinities. The fuperior agent, however, is not able to exercife an unlimited authority over the chemical powers; fometimes they are too ftrong for it: fome fubftances accordingly, as madder, make their way into the fyftem; while others, as arfenic, decompofe and deftroy the organs of the body themfelves.

But it is not in digeftion alone that this fuperior agent makes the moft wonderful difplay of its power; it is in the laft part of affimilation that our admiration is moft powerfully excited. How comes it that the precife fubftances wanted are always carried to every organ of the body? How comes it that fibrina is always regularly depofited in the mufcles, and phofphat of lime in the bones? And what is ftill more unaccountable, how comes it that prodigious quantities of fome one particular fubftance are formed and carried to a particular place in order to fupply new wants which did not before exift? A bone, for example, becomes difeafed and unfit for the ufe of the animal; a new bone therefore is formed in its place, and the old one is carried off by the abforbents. In order to form this new bone, large quantities of phofphat of lime are depofited in a place where the fame quantity was not before neceffary. Now, who informs this agent that an unufual quantity of phofphat of lime is neceffary, and that it muft be carried to that particular place? Or granting, as is moft probable, that the phofphat of lime of the old bone is partly employed for this purpofe, who taught this agent that the old bone muft be carried off, new modelled, and depofited, and affimilated anew? The fame wonders take place during the healing of every wound, and the renewing of every difeafed part.

Thefe operations are incompatible with the fuppofition that the body of animals is a mere chemical and mechanical machine; and demonftrate the prefence of fome agent befides, which acts according to very different laws.

But neither in this cafe is the power of this agent over the chemical agents, which are employed, abfolute. We may prevent a fractured bone from healing by giving the patient large quantities of acids. And unlefs the materials for the new wanted fubftances be fupplied by the food, they cannot, in many cafes, be formed at all. Thus the canary bird cannot complete her eggs unlefs fhe be furnifhed with lime.

It is evident that the fupreme agent of the animal body, whatever that agent may be, acts according to fixed laws; and that when thefe laws are oppofed by thofe which are more powerful, it cannot overcome them. Thefe laws clearly indicate defign; and the agent has the power of modifying them fomewhat according to circumftances. Thus more phofphat of lime is fent to a limb which requires a new bone, and more lime than ufual is taken into the fyftem when the hen is laying eggs. Defign and contingency are confidered by us as infallible marks of confcioufnefs and intelligence. That they are infallible marks of the agency of mind is certain: but that they are in all cafes the proofs of immediate confcioufnefs and intelligence, as the Stahlians fuppofed, cannot be affirmed with outrunning into inconfiftencies. For we ourfelves are not confcious of thofe operations which take place during *affimilation.*

To fay that a being can act with defign without intelligence, we allow to be a flat contradiction, becaufe defign always implies intelligence. There muft therefore be intelligence fomewhere. But may not this intelligence exift, not in the agent, but in the being who formed the agent? and may not the whole of the defign belong in reality to that being?

368 Nor material.

May not this agent, then, be material, and may not the whole of affimilation be performed by mere matter, acting according to laws given it by its maker? We anfwer, that what is called *matter*, or the fubftances enumerated in the firft part of CHEMISTRY (*Suppl.*) act always according to certain attractions and repulfions, which are known by the name of mechanical and chemical laws.

The phenomena of affimilation are fo far from being cafes of thefe laws, that they are abfolutely inconfiftent with them, and contrary to them; confequently the agent which prefides over *affimilation* is not *matter.* Concerning the nature of this fubftance it is not the bufinefs of this article to inquire; but as it poffeffes properties different from matter, and acts according to very different laws, it would be an abufe of terms to call it *matter.* 369

Animal principle.

We fhould give it the name of *mind*, were it not that metaphyficians have chofen to confider intelligence as the effence of mind; whereas this fubftance may be conceived to act, and really does act, without intelligence. There is no reafon, however, to fuppofe, with fome, that there are two fubftances in animals: one poffeffed of confcioufnefs as its effence, and therefore called *mind* or *foul* in man; another, deftitute of confcioufnefs, called the *living principle*, &c. employed in performing the different functions of affimilation, abforption, &c. It is much more reafonable to fuppofe, that in every animal and vegetable there is a peculiar fubftance, different from matter, to which their peculiar properties are owing; that this fubftance is different in every fpecies of animal and vegetable; that it is capable of acting according to certain fixed laws which have been impofed upon it by its Creator, and that thefe laws are of fuch a nature that it acts in fubfervience to a particular end; that this fubftance in plants is probably deftitute of intelligence; that in man and other animals it poffeffes intelligence to a certain extent, but that this intelligence is not effential to its exiftence nor to its activity; that it may be deprived of intelligence altogether, and afterwards recover it without altering its nature. Phyfiologifts have given it the name of *living principle*, becaufe its prefence conftitutes life. Perhaps it would be proper to diftinguifh that of animals by the name of *animal principle.* Upon what the intelligence of the animal principle depends, it is impoffible to fay; but it is evidently connected with the ftate of the brain. During a trance, or an apoplectic fit, it has often been loft for a time, and afterwards recovered.

370 Secretion.

17. Befides affimilation, the blood is alfo employed in forming all the different fecretions which are neceffary for the purpofes of the animal economy. Thefe have been enumerated in the laft chapter. The procefs is fimilar to that of affimilation, and undoubtedly the agents in both cafes are the fame; but we are equally

ecompofi-on of Ani-al Sub-ances. equally ignorant of the precife manner in which fecretion is performed as we are of affimilation.

371. Animals at length die, and why. 18. After thefe functions have gone on for a certain time, which is longer or fhorter according to the nature of the animal, the body gradually decays, at laft all its functions ceafe completely, and the animal dies. The caufe of this muft appear very extraordinary, when we confider the power which the animal has of renewing decayed parts; for it cannot be doubted that death proceeds, in moft cafes at leaft, from the body becoming incapable of performing its function. But if we confider that this power is limited, and that it muft ceafe altogether, when thofe parts of the fyftem begin to decay which are employed in preparing materials for future affimilation, our furprife will, in fome meafure, ceafe. It is in thefe parts, in the organs of digeftion and affimilation accordingly, that this decay ufually proves fatal. The decay in other parts deftroys life only when the wafte is fo rapid that it does not admit of repair.

What the reafon is that the decay of the organs caufes death, or, which is the fame thing, caufes the living principle either to ceafe to act, or to leave the body altogether, it is perfectly impoffible to fay, becaufe we know too little of the nature of the living principle, and of the manner in which it is connected with the body. The laft is evidently above the human underftanding, but many of the properties of the living principle have been difcovered; and were the facts already known properly arranged, and fuch general conclufions drawn from them as their connection with each other fully warrant, a degree of light would be thrown upon the animal economy which thofe, who have not attended to the fubject, are not aware of.

No fooner is the animal dead, than the chemical and mechanical agents, which were formerly fervants, ufurp the fupreme power, and foon decompofe and deftroy that very body which had been in a great meafure reared by their means. But the changes which take place upon animal bodies after death, are too important, and too intimately connected with the fubject of this article to be paffed over flightly. They fhall therefore form the fubject of the next chapter.

CHAP. IV. OF THE DECOMPOSITION OF ANIMAL SUBSTANCES.

372 Decompofition of animal fubftances expofed to the air. ALL the foft and the liquid parts of animals, when expofed to a moderate temperature of fixty-five degrees or more, pafs with more or lefs rapidity through the following changes. Their colour becomes paler, and their confiftence diminifhes; if it be a folid part, fuch as flefh, it foftens, and a ferous matter fweats out, whofe colour quickly changes; the texture of the part becomes relaxed, and its organization deftroyed; it acquires a faint difagreeable fmell; the fubftance gradually finks down, and is diminifhed in bulk; its fmell becomes ftronger and ammoniacal. If the fubject be contained in a clofe veffel, the progrefs of putrefaction, at this ftage, feems to flacken; no other fmell but that of a pungent alkali is perceived; the matter effervefces with acids, and converts fyrup of violets to a green. But if the communication with the air be admitted, the urinous exhalation is diffipated, and a peculiar putrid fmell is fpread around with a kind of impetuofity; a fmell of the moft infupportable kind, which lafts a long time, and pervades every place, affecting the bodies of living animals after the manner of a ferment, capable of altering the fluids: this fmell is corrected, and as it were confined by ammonia. When the latter is volatilized, the putrefactive procefs becomes active a fecond time, and the fubftance fuddenly fwells up, becomes filled with bubbles of air, and foon after fubfides again. Its colour changes, the fibrous texture of the flefh being then fcarcely diftinguifhable; and the whole is changed into a foft, brown, or greenifh matter, of the confiftence of a poultice, whofe fmell is faint, naufeous, and very active on the bodies of animals. The odorant principle gradually lofes its force; the fluid portion of the flefh affumes a kind of confiftence, its colour becomes deeper, and it is finally reduced into a friable matter, rather deliquefcent, which being rubbed between the fingers, breaks into a coarfe powder like earth. This is the laft ftate obferved in the putrefaction of animal fubftances; they do not arrive at this term but at the end of a confiderable time †.

† *Fourcroy*.

373 Buried in the earth. In carcafes buried in the earth, putrefaction takes place much more flowly; but it is fcarcely poffible to obferve its progrefs with accuracy. The abdomen is gradually dilated with elaftic fluids which make their appearance in it, and at laft it burfts and difcharges a horribly fetid and noxious gas; at the fame time a dark coloured liquid flows out. If the earth be very dry, and the heat confiderable, the moifture is often abforbed fo rapidly, that the carcafe, inftead of putrefying, dries, and is transformed into what is called a *mummy*.

374 When accumulated together. Such are the phenomena when dead bodies are left to putrefy feparately. But when great numbers of carcafes are crowded together in one place, and are fo abundant as to exclude the action of external air, and other foreign agents, their decompofition is entirely the confequence of the reciprocal action of their ingredients themfelves upon each other, and the refult is very different. The body is not entirely diffipated or converted into mould, but all the foft parts are found diminifhed remarkably in fize, and converted into a peculiar *faponaceous matter*. This fingular change was firft accurately obferved in the year 1786.

375 Converted into a faponaceous matter. The burial ground of the Innocents in Paris having become noxious to thofe who lived in its neighbourhood, on account of the difagreeable and hurtful odour which it exhaled, it was found neceffary to remove the carcafes to another place. It had been ufual to dig very large pits in that burial ground, and to fill them with the carcafes of the poorer fort of people, each in its proper bier; and when they were quite full, to cover them with about a foot depth of earth, and to dig another fimilar pit, and fill it in the fame manner. Each pit held between 1000 and 1500 dead bodies. It was in removing the bodies from thefe pits that this faponaceous fubftance was found. The grave-diggers had afcertained, by long experience, that about thirty years were required before all the bodies had undergone this change in its full extent *. Every part of the body acquired the properties of this fubftance. The inteftines and vifcera of the thorax had completely difappeared; but what is fingular enough, the brain had loft but little of its fize or appearance, though it was alfo converted into the fame fubftance.

* *Fourcroy*, *Ann. de Chim.* v. 154.

376 Its properties. This faponaceous matter was of a white colour, foft and unctuous to the touch, and melted, when heated, like

Decomposition of Animal Substances.

like tallow. It exhibited all the properties of a *soap*, containing, however, an excess of fatty matter. Fourcroy, who analysed it, found that it was composed of a fatty matter combined with ammonia, and that it contained also some phosphat of lime and ammonia. Diluted acids decomposed it, and separated the fatty matter: alkalies and lime, on the other hand, drove off the ammonia. When exposed to the air, it gradually lost its white colour; the ammonia, in a great measure, evaporated, and what remained had something of the appearance of wax. It absorbed water with great avidity, and did not part with it readily. Its white colour was owing to the presence of that liquid. The oily matter, when separated by means of a diluted acid, was concrete, and of a white colour, owing to the mixture of a quantity of water. When dried, it acquires a greyish brown colour, a lamellar and crystalline texture, like that of spermaceti; but if it has been rapidly dried it assumes the appearance of wax. It melts, when heated, to 126°; when properly purified, by passing it through a linen cloth while fluid, it has scarcely any smell. Alcohol does not act upon it while cold, but at the temperature of 120° it dissolves it: when the solution cools, the fatty matter precipitates, and forms a gritty mass. With alkalies it forms a soap; and when set on fire it burns precisely like oil or fat, only that it exhales a more unpleasant odour †.

† Fourcroy, Ann. de Chim. viii. 17.

377 Produced also in running water.

Mr Smith Gibbes found the same substance in the pit into which animal matters are thrown at Oxford after dissection. A small stream of water constantly passes through this pit; a circumstance which induced him to try whether animal muscle exposed to the action of a running stream underwent the same change. The experiment succeeded completely: he attempted, in consequence, to render this substance, to which he gave the name of *spermaceti*, useful in those manufactures which required tallow; but the fetid odour which it constantly exhales was an insurmountable objection. Attempts were indeed made to get over it; but as we do not hear that Mr Smith Gibbes's spermaceti has been introduced into any manufacture, we have reason to conclude that none of these attempts succeeded ‡.

‡ Phil. Transf. 1794 and 1795.

378 Theory of putrefaction imperfect.

Such are the phenomena of putrefaction, as far as they are at present known to chemists. Any attempt to explain the manner in which these changes take place, would be exceedingly imperfect indeed; not only because we are ignorant of the strength of the affinities of the different elementary parts of animal bodies for each other, but because we do not even know the manner in which these elements are combined, and consequently we cannot know by what particular forces these compounds are destroyed. We know only that a certain degree of heat, and the presence of moisture, are in all cases necessary for the putrefactive process; for animal bodies may be kept almost any length of time, without decomposition, at the freezing temperature; and when dried quickly, and kept in that state, they undergo no farther change.

PART III. OF DYEING.

MANKIND have in all periods of society manifested a fondness for beautiful and gaudy colours. Naked savages at first applied them to their skin. This was the case with the Britons, and with the Guals, too, in the time of Cæsar; it is even still the practice in the South Sea islands, and many parts of America. When mankind had advanced so far towards civilization as to wear garments, they naturally transferred to them the colours which they admired. Hence the origin of *dyeing*; which is of such antiquity, that it precedes the earliest records left us by profane authors. We see from the book of Genesis the great progress which it had made in the time of the patriarchs.

379 Origin of dyeing.

Dyeing seems to have originated in India, and to have spread gradually from that country to the west. The Indians were the inventors of the method of dyeing cotton and linen, which was not understood in Europe before the conquests of Alexander the Great. The Phenicians excelled in the art at a very early period. It was from them that the Jews purchased all the dyed stuffs described in Exodus. The Phenician dyers seem to have confined their art to wool: silk was unknown to them, and linen was usually worn white. From them the art of dyeing passed to the Greeks and Romans.

During the fifth century, the Western Empire was overturned by the northern nations, and with it the arts and sciences, which had flourished under the protection of the Romans, disappeared. A few of the arts, indeed, were preserved in Italy, but they were obscured and degraded. By degrees, however, a spirit of industry began to revive in that country. Florence, Genoa, and Venice, becoming rich commercial cities, carried on a considerable intercourse with the Grecian empire, where many of the arts had been preserved. This intercourse was much increased by the crusades. The Italian cities became rich and powerful: the arts which distinguish civilized nations were cultivated with emulation, and dyeing, among others, was rapidly improved.

380 Its progress in modern Europe.

In the year 1429, the first treatise on dyeing made its appearance at Venice, under the name of *Moriegola del arte de tentori*. Giovanne Ventura Rosetta collected, with great industry, all the processes employed by the dyers of his time, and published them in 1548, under the title of *Plictho* *. For many years dyeing was almost exclusively confined to Italy; but it gradually made its way to France, the Low Countries, and to Britain. The minister Colbert, who employed his talents in extending the commerce and manufactures of France, paid particular attention to the art of *dyeing*. In the year 1672, he published a table of instructions, by which those who practised the art were laid under several very improper restrictions. But the bad effects of these were in a good measure obviated by the judicious appointment of men of science to superintend the art. This plan, begun by Colbert, was continued by the French government. Accordingly, Dufay, Hellot, Macquer, and Berthollet, successively filled the office. It is to this establishment, and to exertions of the celebrated chemists who have filled it, that France is indebted for the improvements she has made in the art of dyeing during the course of the 18th century. Under the direction of Dufay, a new table of regulations was published in 1737, which superseded that of Colbert.

* Berthollet on Dyeing, i. 22.

Hellot,

Substances used for Clothing.

Hellot, his fucceffor, publifhed, in 1740, an excellent fyftem of dyeing wool; and Macquer in 1763 publifhed his treatife on dyeing filk.

In Britain, though dyeing has been carried on for many years with great fuccefs, very little progrefs was made in inveftigating the theory of the art. The Royal Society, indeed, foon after its inftitution, recommended it to fome of its members; but as no treatife made its appearance in confequence of this, it feems very foon to have loft their attention. Lewis, many years after, publifhed fome very important remarks on dyeing; but they were confined to a few proceffes. The Britifh dyers fatisfied themfelves with a tranflation of Hellot. Such was the ftate of the art when the article DYEING in the *Encyclopædia* was drawn up. It confifts chiefly of an abftract of Hellot's treatife. But within the laft 30 years, the attention of men of fcience has been very much turned to this complicated art. In Sweden has appeared the treatife of Scheffer, and Bergman's notes on it; in Germany, the experiments of Beckmann, Poerner, and Vogler, and the differtation of Franchéville; in France, the treatifes of D'Ambournay, D'Apligny, Hauffmann, Chaptal, and, above all, of Berthollet; in this country, the ingenious remarks of Delaval, of Henry, and the valuable treatife of Dr Bancroft; befides many other important effays. Thefe, together with the progrefs of the fcience of chemiftry, on which the theory of dyeing depends, have thrown fo much new light upon the art, that we find ourfelves under the neceffity of tracing the whole over again. We fhall pafs over, however, very flightly thofe parts of the art which have been fufficiently explained in the article DYEING, *Encycl.*

To underftand the art of *dyeing*, we muft be acquainted with the *fubftances* on which it is practifed, with the nature of *colour*, and with the method of permanently changing the colour of bodies. Thefe three things we fhall confider in the three following chapters. In the firft, we fhall give an account of the fubftances of which garments are ufually made, with which alone the art of dyeing is concerned; in the fecond, we fhall inquire into the nature of colour; and in the third, explain the theory of dyeing, as far as it is at prefent underftood. In fome fubfequent chapters, we fhall give a general view of the proceffes by which the different colours are given to ftuffs.

CHAP. I. OF THE SUBSTANCES USED FOR CLOTHING.

THE fubftances commonly employed for clothing may be reduced to four; namely, *wool*, *filk*, *cotton*, *linen*. As there is no name in the Englifh language which includes all thefe fubftances, we fhall take the liberty, in the remainder of this article, to ufe the word *cloth* for that purpofe. They are all made into *cloth*, of fome kind or other, before they can be ufeful as articles of *clothing*.

1. WOOL, as is well known, is the hair which covers the bodies of fheep; it differs from common *hair* merely in finenefs and foftnefs. Its filaments poffefs a confiderable degree of elafticity; they may be drawn out beyond their ufual length, and afterwards recover their form when the external force is removed. The furface of wool and hair is by no means fmooth: No inequality, indeed, can be perceived by a microfcope; nor is any refiftance felt when a hair is laid hold of in one hand, and drawn between the fingers of the other, from the *root* towards the *point*; but if it be drawn from the *point* towards the *root*, a refiftance is felt which did not take place before, a tremulous motion is perceived, and a noife may be diftinguifhed by the ear. If, after laying hold of a hair between the thumb and fore finger, we rub them againft each other in the longitudinal direction of the hair, it acquires a progreffive motion *towards the root*; the *point* gradually approaches the fingers, while the *root* recedes from them; fo that the whole hair very foon paffes through between the fingers.

Thefe obfervations, firft made by Mr Monge, demonftrate that the furface of hair and wool is compofed, either of fmall laminæ, placed over each other in a flanting direction from the root towards the point, like the fcales of a fifh—or of zones, placed one above another, as takes place in the horns of animals *.

* Ann. de Chim. vi. 300.

On this ftructure of the filaments of hair and wool depend the effects of *felting* and *fulling*. In both of thefe operations, the filaments are made, by an external force, to rub againft each other; the pofition of their afperities prevents them from moving, except in one direction: they are mutually entangled, and obliged to approach nearer each other. Hence the thicknefs which cloth acquires in the fulling mill. The filaments have undergone a certain degree of felting, and are interwoven like the fibres of a hat. The cloth is contracted both in length and breadth: it may be cut without being fubject to ravel; nor is there any neceffity for hemming the different pieces employed to make a garment. See FELTING and FULLING in this *Suppl.*

Wool is naturally covered with a kind of greafe, which preferves it from moths. This is always removed before the wool is dyed; becaufe its prefence is very prejudicial to the fuccefs of that operation. The afperities of the furface of woolly fibres would impede the converting of it into thread by fpinning; but they are in a great meafure covered, previous to that operation, by foaking the wool with oil. The oil muft alfo be removed before the wool be dyed. This procefs is called SCOURING, which fee in this *Suppl.*

We have already, in the fecond part of this article, given an account of what is at prefent known concerning the compofition of wool and hair. It would be foreign to the fubject of this chapter, to defcribe the method of *fpinning* and *weaving* wool.

Wool is of different colours; but that which is white is preferred for making cloth; becaufe it anfwers better for the purpofes of dyeing than any other kind.

383 Silk.

2. SILK is a fubftance fpun in fine threads by the *filk worm*. Its fibres are not fcaly like thofe of wool; neither have they the fame elafticity: but filk, in its natural ftate, before it has undergone any preparation, has a confiderable degree of ftiffnefs and elafticity. In this ftate it is known by the name of *raw filk*. It is covered with a kind of gummy varnifh, which may be removed by fcouring with foap. The fcouring deprives it of its ftiffnefs and elafticity. Raw filk is of a yellow colour, owing to yellow refinous matter with which it is naturally combined. We have given the method of feparating this matter, and alfo the gum, in the article BLEACHING, *Supplement.*

Silk, before it is dyed, is always freed from its gum, and generally alfo from its refin. It may be dyed without

Subſtances uſed for Clothing. out the application of heat; which is not the caſe with cotton, and linen. The firſt two are animal ſubſtances; the two laſt vegetable. The animal contain much azot and hydrogen; the vegetable much carbon: The animal are readily deſtroyed by acids and alkalies; the vegetable withſtand the action of theſe ſubſtances better; even nitric acid does not readily deſtroy the texture of cotton. The animal ſubſtances are more eaſily dyed than the vegetable, and the colours which they receive are more permanent than thoſe given to cotton and linen by the ſame proceſſes.

Such are the properties of the cloths on which the art of dyeing is exerciſed. But what is the nature of theſe *colours* which it is the object of that art to communicate? We ſhall examine this ſubject in the following chapter.

Colour... wool.

384 Cotton, 3. COTTON is a fine downy ſubſtance, contained in the pods of different ſpecies of goſſypium. The ſpecies from which the greater part of the cotton brought to this country is taken is the *herbaceum*. The quantity imported annually into Britain is very great; in 1786 it amounted to 20 millions of pounds ‡. Cotton varies greatly, according to the plant on which it grows, and the climate where it is cultivated. The chief differences are in colour, and in the length, fineneſs, and ſtrength of the filaments.

‡ *Bancroft*, i. 69.

No aſperities can be diſcovered on the ſurface of theſe filaments; but Lewenhoeck obſerved, by means of a microſcope, that they are triangular, and have three ſharp edges. This is probably the reaſon of a well known fact, that cotton cloth, when applied by way of dreſſing, always irritates a ſore.

Some cottons are naturally white; others a fine light yellow, as thoſe of which nankeen is made; but moſt commonly cotton is of a dirty browniſh yellow colour, which muſt be removed before the ſtuff can be dyed. This is done by the proceſs of *bleaching*. The fibres of cotton, even after being bleached, retain almoſt always ſome lime and oxide of iron, which muſt be removed before we attempt to dye the cotton; becauſe their preſence would ſpoil the colour. This is done by ſteeping the cotton for ſome time in water acidulated with ſulphuric acid.

Cotton, like ſilk, may be dyed without the aſſiſtance of heat. It is not nearly ſo eaſy to dye cotton any particular colour as it is to dye wool or ſilk. If wool and cotton be put into the ſame dyeing veſſel, the wool frequently acquires the wiſhed-for colour before the cotton has loſt any of its original whiteneſs.

385 Linen. 4. LINT, from which *linen* is made, is the inner bark of the *linum uſitatiſſimum*, or *flax*; a plant too well known in this country to require any deſcription.

The flax, when ripe, is pulled and ſteeped for ſome days in water, in order to ſeparate the green coloured glutinous matter which adheres to the inner bark. This matter undergoes a degree of putrefaction; carbonic acid gas and hydrogen gas are diſengaged *: it is decompoſed, and carried off by the water. If the water, in which the flax is ſteeped, be completely ſtagnant, the putrefaction is apt to go too far, and to injure the fibres of the lint; but in a running ſtream, it does not go far enough, ſo that the green matter ſtill continues to adhere to the lint. Flax, therefore, ſhould be ſteeped in water neither completely ſtagnant, nor flowing too freely, like a running ſtream.

* *Rozer.*

The flax is afterwards ſpread upon the graſs, and expoſed for ſome time to the air and ſun: this improves the colour of the lint, and renders the woody part ſo brittle, that it is eaſily ſeparated by the action of the lint mill. The ſubſequent operations, of *dreſſing*, *ſpinning*, *weaving*, and *bleaching*, do not belong to this article.

The fibres of lint have very little elaſticity. They appear to be quite ſmooth; for no aſperities can be perceived by the microſcope, nor detected by the feel; nor does linen irritate ſores, as is the caſe with cotton.

Linen may be dyed without the aſſiſtance of heat; but it is more difficult to give it permanent colours than even cotton.

Thus we have given a ſhort deſcription of wool, ſilk,

CHAP. II. OF COLOURS.

ALL viſible objects, as has been long ago ſufficiently eſtabliſhed, are ſeen by means of rays of light paſſing off from them in all directions, and partly entering the eye of the ſpectator.

1. For the theory of light and viſion we are indebted to Sir Iſaac Newton. He firſt demonſtrated, that light is compoſed of ſeven rays, differing from each other in refrangibility, and other properties. Each of theſe rays is diſtinguiſhed by its particular colour. Hence their names, red, orange, yellow, green, blue, indigo, violet. By mixing together theſe different rays, in various proportions, all the colours known may be obtained. Thus red and yellow conſtitute orange; yellow and blue conſtitute green; blue and red conſtitute purple, violate, aurora, &c. according to their proportions. When all the rays are mixed together, they form a white. 386 Colour produced by light.

2. Bodies differ very much from each other in their power of reflecting light. Some reflect it in vaſt quantity, as metals; others reflect but little, as charcoal. In general, the ſmoother the ſurface of a body is, the greater is the quantity of light which it reflects. Hence the effect of poliſhing in increaſing the brightneſs of bodies. But it is not in the quantity of the light reflected alone that bodies differ from each other; they differ alſo in the quality of the light which they reflect. Some bodies reflect one or more particular ſpecies of ray to the excluſion of the reſt. This is the reaſon that they appear to us of different colours. Thoſe bodies which reflect only red rays are red; thoſe that reflect yellow rays are yellow; thoſe that reflect all the rays equally are white; thoſe that reflect too little to affect the eye are black. It is to the different combinations of rays reflected from the ſurface of bodies that all the different ſhades of colour are owing. 387 Bodies reflect different rays.

Colour, then, in *opaque* bodies, is owing to their diſpoſition to *reflect* certain rays of light, and to *abſorb* the reſt; in *tranſparent* bodies, to their diſpoſition to *tranſmit* certain rays, and to *abſorb* the others. But this ſubject has been diſcuſſed, at ſufficient length, in the article OPTICS, *Encycl.*; to which, therefore, we beg leave to refer the reader. Here we mean only to inquire into the *cauſe* of this diſpoſition of the particles of bodies. 38[8] Hence the different colours.

3. Sir Iſaac Newton, to whom we are indebted for the exiſtence of optics as a ſcience, made a ſet of experiments to aſcertain the changes of colour which thin plates of matter aſſume in conſequence of an increaſe or dimi- 3[89] Newton's theory explaining different

urs. diminution of their thicknefs. Thefe experiments were of a very delicate nature; but Newton conducted them with fo much addrefs, and varied and repeated them with fo much induftry, that he was enabled to render them furprifingly accurate.

Upon a large double convex lens of a 50 feet focus, he placed the plane furface of a planoconvex lens, and preffed the lenfes flowly together. A circle, of a particular colour, appeared in the centre, where the two glaffes touched each other. This circle gradually increafed in diameter as the preffure was augmented; and at laft a new circle, of another colour, occupied the centre, while the firft colour affumed the form of a circular ring. By increafing the preffure, a new coloured circle appeared in the centre, and the diameter of the other two increafed. In this manner he proceeded, till he produced no lefs than 25 different coloured circular rings. Thefe he divided into feven orders, on account of the repetition of the fame colour. They were as follows, reckoning from the central colour, which was always black *.

*wton's s, 191. ke's on.

1. Black, blue, white, yellow, red.
2. Violet, blue, green, yellow, red.
3. Purple, blue, green yellow, red.
4. Green, red.
5. Greenifh blue, red.
6. Greenifh blue, pale red.
7. Greenifh blue, reddifh white.

Thefe different colours were occafioned by the thin film of air between the two glaffes. Now this film varies in thicknefs from the centre of the lens towards the circumference; that part of it which caufes the black colour is thinneft, and the other coloured circles are occafioned by air gradually increafing in thicknefs. Newton meafured the *relative thicknefs* of the air which produced each of thefe coloured circles; and he found it as follows †:

†d, p.

1. Black	1	green	$25\frac{1}{5}$
blue	$2\frac{2}{5}$	yellow	$27\frac{1}{7}$
white	$5\frac{1}{3}$	red	31
yellow	$7\frac{1}{9}$	4. Green	35
red	$8\frac{1}{2}$	red	$40\frac{1}{3}$
2. Violet	$11\frac{1}{6}$	5. Gr. blue	46
blue	14	red	$52\frac{1}{2}$
green	$15\frac{1}{8}$	6. Gr. blue	$58\frac{3}{4}$
yellow	$16\frac{2}{7}$	red	65
red	$18\frac{1}{3}$	7. Gr. blue	71
3. Purple	21	reddifh white	77
blue	$23\frac{2}{5}$		

The *abfolute* thicknefs of thefe films cannot be afcertained, unlefs the diftance between the two glaffes, at that part where the black fpot appears, were known. Now there is no method of meafuring this diftance; but it certainly is not greater than the thoufandth part of an inch.

He repeated thefe experiments with films of water, and even of glafs, inftead of air; and he found, that in thefe cafes the thicknefs of the films, reflecting any particular colour, was diminifhed, and that this diminution was proportional to the denfity of the reflecting film.

From thefe experiments Sir Ifaac Newton concluded, that the difpofition of the particles of bodies to reflect or tranfmit particular rays depended upon their fize and their denfity: and he even attempted to afcertain the fize, or at leaft the thicknefs, of the particles of bodies from their colours. Thus a particle of matter, whofe denfity is the fame with that of glafs which reflects a green of the third order, is of the thicknefs of $\frac{16\frac{1}{4}}{10000000}$ of an inch *. Colours.

* Newton's Optics, 251.

In the year 1765, Mr Delaval publifhed, in the Philofophical Tranfactions, a very ingenious paper on the fame fubject. In this paper, he endeavours to prove, by experiment, that the colours of metallic bodies depend upon their denfity. He takes it for granted, at the fame time, that the fize of the particles of bodies is inverfely as the denfity of bodies. The denfeft bodies, according to him, are red; the next in denfity, orange; the next, yellow; and fo on, in the order of the refrangibility of the different rays. Some time after, the fame ingenious gentleman, in his *Experimental Inquiry into the Caufe of the Permanent Colours of Opaque Bodies*, extended his views to animal and vegetable fubftances, and endeavoured to prove the truth of Newton's theory by a very great number of experiments.

Such is a view of the opinion of Newton and Delaval refpecting the caufe of bodies reflecting or tranfmitting particular rays of light, as far, at leaft, as that theory relates to colour. They afcribed this caufe *folely* to the *fize* and the *denfity* of the particles of bodies.

By *particles*, it is evident that nothing elfe can be meant than the *integrant particles* of bodies. Newton, indeed, does not exprefs himfelf precifely in this language; but it is plain that nothing elfe could be his meaning. Mr Delaval undoubtedly is of that opinion.

According to the Newtonian theory of colour, then, it depends folely upon the *fize* of the integrant particles of bodies whofe denfity is the fame; and upon the *fize* and the *denfity* jointly of all bodies (T).

39? Examined.

It is evident that the truth of the Newtonian theory muft depend upon its coincidence with what actually takes place in nature, and that therefore it can only be determined by experiment. Newton himfelf produced but very few experiments in fupport of it; and though this deficiency was amply fupplied by Mr Delaval, it is needlefs for us to adduce any of thefe here; becaufe, from the prodigious accumulation of chemical facts fince thefe experiments were made, the very bafis upon which they ftood has been deftroyed, and confequently all the evidence refulting from them has been annihilated. They proceeded on the fuppofition, that acids render the particles of bodies *fmaller*, and alkalies *larger* than they were before, without producing any other change whatever in the bodies on which they act. To attempt a refutation of this opinion at prefent would be unneceffary, as it is well known not to be true.

Let us therefore compare the Newtonian theory of colour with thofe chemical changes which we know for certain to alter the fize of the particles of bodies, in order to fee whether they coincide with it. If the theory be true, the two following confequences muft hold

(T) Newton, however, pointed out an exception to this law, concerning which Mr Delaval has been more explicit. Combuftible bodies do not follow that law, but fome other. Mr Delaval has fuppofed, that this deviation is owing to the prefence of phlogifton.

Colours.

hold in all caſes: 1. Every alteration in the ſize of the integrant particles of bodies muſt cauſe theſe particles to aſſume a different colour. 2. Every ſuch alteration muſt correſpond preciſely with the theory; that is to ſay, the new colour muſt be the very colour, and no other, which the theory makes to reſult from an increaſe or diminution of ſize.

391
And found defective.

Now neither of theſe conſequences holds in fact. We have no method indeed of aſcertaining the ſizes of the integrant particles of bodies, nor of meaſuring the preciſe degree of augmentation or diminution which they ſuffer; but we can in many caſes aſcertain, whether any new matter has been added to a particle, or any matter abſtracted from it; and conſequently whether it has been augmented or diminiſhed; which is ſufficient for our preſent purpoſe.

For inſtance, whatever be the ſize of an integrant particle of gold, it cannot be denied that an integrant particle of oxide of gold is greater; becauſe it contains an integrant particle of gold combined with at leaſt one integrant particle of oxygen. Now the colour both of gold and of its oxide is yellow, which ought not to be the caſe, according to the Newtonian theory. In like manner, the amalgam of ſilver is white, preciſely the colour of ſilver and of mercury; yet an integrant particle of the amalgam muſt be larger than an integrant particle either of ſilver or of mercury. Many other inſtances beſides theſe will occur to every one, of changes in the ſize of the particles taking place without any change of colour. All theſe are incompatible with the Newtonian theory.

It may be ſaid, perhaps, in anſwer to this objection, that there are different orders of colours; that the ſame colour is reflected by particles of different ſizes; and that the increaſed particles, in the inſtances above alluded to, retain their former colour, becauſe the increment has been preciſely ſuch as to enable them to reflect the ſame colour in the next higher order.

This very anſwer is a complete proof that the Newtonian theory is not ſufficient to account for the colours of bodies; for if particles of *different* ſizes reflect the ſame colour, *ſize* certainly is not the only cauſe of this reflection *. There muſt be ſome other cauſe very different from ſize. Nor is this all; the moſt common colour which remains after an increaſe of the ſize of the integrant particles of bodies is white; yet white does not appear in any of the orders except the firſt, and therefore its permanence cannot be accounted for by any ſuppoſition compatible with the Newtonian theory.

* *Bancroft on Permanent Colours*, i. 7.

Even when alterations in the colour of bodies accompany the increaſe or diminution of the ſize of their particles, theſe alterations ſeldom or never follow an order which correſponds with the theory. As for metals, it is ſelf-evident that their colour does not depend upon their denſity. Platinum is the denſeſt body known, and yet it is not red, as it ought to be, but white like tin; a metal which has little more than one third of the denſity of platinum.

The green oxide of iron, when combined with pruſſic acid, becomes white; yet the ſize of its particles muſt be increaſed. Now this change of colour is incompatible with the theory; for, according to it, every change from green to white ought to be accompanied by a diminution inſtead of an increaſe of ſize. A particle of indigo, which is naturally green, becomes blue by the addition of oxygen, which muſt increaſe its ſize. This change is alſo incompatible with the theory. But it is unneceſſary to accumulate inſtances, as they will naturally occur in ſufficient number to every one.

It follows irreſiſtibly from theſe facts, that the Newtonian theory is not ſufficient to explain the *cauſe* of colour; or what cauſes bodies to reflect or tranſmit certain rays, and to abſorb the reſt.

392
Bodies owe their colour to their affinity for light.

4. We have endeavoured, in the article CHEMISTRY, *Suppl.* to ſhew, that bodies have a particular affinity for the rays of light; and that the phenomena of light depend entirely upon theſe affinities. Indeed this conſequence follows from the properties of light eſtabliſhed by Newton himſelf. We ſhall not repeat here the proofs upon which the exiſtence of theſe affinities is founded: the reader may eaſily ſatiſfy himſelf by conſulting the article above referred to.

Every coloured body, then, has a certain *affinity for* ſome of the rays of light. Thoſe rays for which it has a ſtrong affinity are abſorbed by it and retained, and the other rays for which it has no affinity are either reflected or tranſmitted, according to the nature of the body and the direction of the incident ray. Thus a red body has an affinity for all the rays except the red; it abſorbs therefore the other ſix, and reflects only the red: a green body abſorbs all but the green rays, or perhaps the red and yellow: a black body has a ſtrong affinity for all the rays, and therefore abſorbs them all; while a white body, having no ſtrong affinity for any of the rays, reflects or tranſmits them all.

If affinity, as we have endeavoured to ſhew in the article CHEMISTRY, *Suppl.* be an attraction of the ſame nature with gravitation, and increaſing as the diſtance diminiſhes, it muſt depend upon the nature of the attracting particles. Now the only differences which we can conceive to exiſt between the particles of bodies, are differences in *ſize*, in *denſity*, and in *figure*. Changes in theſe three things will account for all the varieties of affinity. Now if affinity depends upon theſe three things, and if colour depends upon the affinity between the particles of bodies and the different rays of light, as cannot be denied, it is clear that the cauſe of the colour of bodies may be ultimately reſolved into the ſize, denſity, and figure of their particles. Newton's theory, then, was defective, becauſe he omitted the *figure* of the particles, and aſcribed the whole to variations in *ſize* and *denſity*.

When we ſay, then, that colour is owing to *affinity*, we do not contradict the opinion of Newton, as ſome philoſophers have ſuppoſed, but merely extend it: Newton was *not miſtaken* in ſaying, that colour depends upon the ſize and the denſity of the particles of bodies; his miſtake lay in ſuppoſing that it depends upon theſe *alone*.

393
Why bodies change their colour.

5. Since the colour of bodies depends upon their affinity for light, and ſince every body has a certain colour, becauſe it abſorbs and retains particular rays while it tranſmits or reflects the reſt, it is evident that every body muſt continue of its firſt colour till one of two things happen; either till it be ſaturated with the rays which it abſorbs, and of courſe ceaſe to abſorb any more, or till its particles change their nature, by being either decompoſed or combined with ſome new ſubſtance. We have no poſitive proof that the firſt cauſe

lours. cauſe of change ever occurs, as many ſubſtances have been expoſed to the action of light for a very long time without any change of colour. The abſorbed light ſeems to make its eſcape, either in its own form, or in ſome unknown or unſuſpected one. The ſecond cauſe of change is very common: indeed its action may be detected in almoſt every caſe of alteration in the colour of bodies. The green oxide of iron, by combining with oxygen, becomes red; and this red oxide, when combined with pruſſic acid, aſſumes a blue colour, and with gallic acid a black colour. The cauſe of this change of colour, when the compoſition of a body changes, is obvious: every change of compoſition muſt alter the affinity, becauſe it muſt of neceſſity produce changes in the ſize, denſity, or figure of the particles, or perhaps in all of theſe. Now if the affinity of a body for other bodies be altered, it is natural to ſuppoſe that it will be altered alſo for light. Accordingly this happens in moſt inſtances. It does not, however, take place conſtantly, for very obvious reaſons. It may happen that the new denſity, ſize, or figure of the altered body is ſuch, as to render it ſtill proper for attracting the very ſame rays of light which it formerly attracted. Juſt as iron, after being combined with a certain doſe of oxygen, is converted into green oxide, which ſtill retains an affinity for oxygen.

It is evident from all this, that in moſt caſes the permanence of colour in bodies will depend upon the permanence of their compoſition, or on the degree of facility with which they are acted upon by thoſe bodies, to the agency of which they are expoſed.

394 rmanence of colour great importance in ing.

In *dyeing*, the permanence of colour is of very great importance. Of what value is the beauty of a colour, provided that colour be fugitive or liable to change into ſome other. In all caſes, therefore, it is of conſequence to attend to the ſubſtances to which dyed cloth is expoſed, and to aſcertain their action upon every particular dyeing ingredient. Now the bodies to which dyed cloth is almoſt conſtantly expoſed are *air* and *light;* the combined action of which has ſo much influence, that very few dyes can reſiſt it.

395 w dyes e their lour.

It is evident that thoſe ſubſtances cannot retain their colour, which have ſuch an affinity for oxygen as enables them to take it from atmoſpheric air. Thus the green colour of green oxide of iron and of indigo is not permanent, becauſe theſe ſubſtances readily abſorb oxygen from air. In order, then, that a colour can have any permanence, the coloured body muſt not have ſo great an affinity for oxygen as to be able to take it from air. Thoſe bodies have in general the moſt permanent colours which are already ſaturated with oxygen, and therefore not liable to abſorb more. Such is the caſe with red oxide of iron.

All coloured bodies are compounds; ſome of thoſe only excepted which ſtill retain an affinity for oxygen. Coloured bodies, therefore, are compoſed of ſeveral ingredients; and in every coloured body, at leaſt *ſome* of the ingredients have a ſtrong affinity for oxygen. Now, before the colour of a body can be permanent, its ingredients muſt be combined together by ſo ſtrong affinities, that oxygen gas is unable to decompoſe it by combining with one or more of its ingredients and carrying it off. If this decompoſition take place at once, it is impoſſible for the colour of a body to have any permanence. If it takes place ſlowly, the colour of the body gradually decays. The action of oxygen gas upon bodies is much increaſed in particular circumſtances. Almoſt all coloured bodies are decompoſed by oxygen gas by the aſſiſtance of heat. Thus if wheat flour be expoſed to the heat of 448°, it loſes its white colour, and becomes firſt brown and then black. At this temperature it is decompoſed, and a part, or even the whole of its hydrogen, combining with oxygen, flies off. Cloth is ſcarcely ever expoſed to ſo high a temperature; but there are other circumſtances in which it may be placed which may have a ſimilar effect. Thus the action of light ſeems in ſome ſubſtances to be ſimilar to that of heat, and to facilitate the decompoſition of the coloured matter by the combination of ſome of its ingredients with oxygen *.

Coloured bodies, in order to have permanent colours, muſt not be liable to be decompoſed by other ſubſtances more than by oxygen. For inſtance, if they contain oxygen and hydrogen, theſe two bodies muſt not be liable to combine together and form water, nor muſt oxygen and carbon be liable to combine and form carbonic acid gas. Light ſeems to have a tendency to decompoſe many bodies in this manner, and even to carry off oxygen from them in the form of oxygen gas. Thus it renders the nitrat of ſilver black by carrying off part of its oxygen, and it reduces oxy-muriatic acid to common muriatic acid by the ſame means.

* Berthollet on Dyeing, i. 45.

Theſe are the cauſes which induce a change in the colour of coloured bodies, as far as they have been traced; namely, the addition of oxygen, the abſtraction of oxygen, partial decompoſition by ſome one of their ingredients combining with oxygen, complete or partial decompoſition by the ingredients entering into new combinations with each other. The coloured matters uſed in dyeing are very liable to theſe changes, becauſe they are in general animal or vegetable ſubſtances of a very compound nature. Of courſe their ingredients have often no very ſtrong affinity for each other, and therefore are very liable to decompoſition; and every one of the ingredients has in general a very ſtrong affinity for oxygen. This renders the choice of proper colouring matters for dyeing a very important point. In order to have permanency, they muſt not be liable to the above changes, not to mention their being able alſo to withſtand the action of ſoap, acids, alkalies, and every other ſubſtance to which dyed cloth may be expoſed.

396 Method of aſcertaining the permanency of dyes.

It becomes therefore a point of ſome conſequence to be able to aſcertain whether cloth dyed of any particular colour be permanently dyed or not. The proper method of aſcertaining this is by actually expoſing ſuch cloth to the ſun and air; becauſe as theſe are the agents to which it is to be expoſed, and which have the moſt powerful action, it is clear, that if it withſtand them, the colour muſt be conſidered as permanent. But this is a tedious proceſs. Berthollet propoſed expoſing ſuch cloth to the action of oxy-muriatic acid; thoſe colours that withſtand it being conſidered as permanent. This method anſwers in many caſes: but it is not always to be depended on; for it deſtroys ſome permanent colours very ſpeedily, and does not alter others which are very fading *. But we ſhall have occaſion to reſume this ſubject afterwards.

* Bancroft, i. 49.

397 Diviſion of colours.

Dyers divide colours into two claſſes; namely, *ſimple* and *compound*. The ſimple colours are thoſe which cannot

cannot be produced by the mixture of other colours. They are in number four.

1. Blue, 3. Red,
2. Yellow, 4. Black.

Some add a fifth, *brown;* but it may be produced by combining two others.

The compound colours are thoſe which are produced by mixing together any two ſimple colours in various proportions. They conſtitute all the colours except the four ſimple and their various ſhades.

Thus we have examined the nature of colours; but we have ſtill to explain the method of giving permanent colours to cloth. This ſhall be the ſubject of the next chapter.

CHAP. III. OF DYEING IN GENERAL.

FROM the theory of colour laid down in the laſt chapter, it follows, that permanent alterations in the colour of cloth can only be induced two ways; either by producing a chemical change in the cloth, or by covering its fibres with ſome ſubſtance which poſſeſſes the wiſhed-for colour. Recourſe can ſeldom or never be had to the firſt method, becauſe it is hardly poſſible to produce a chemical change in the fibres of cloth without ſpoiling its texture and rendering it uſeleſs. The dyer, therefore, when he wiſhes to give a new colour to cloth, has always recourſe to the ſecond method.

398 Dye-ſtuffs

1. The ſubſtances employed for this purpoſe are called *colouring matters*, or *dye ſtuffs*. They are for the moſt part extracted from *animal and vegetable ſubſtances*, and have uſually the colour which they are intended to give to the cloth. Thus a blue colour is given to cloth by covering its fibres with indigo, a blue powder extracted from a ſhrub; a red colour, by the colouring matter extracted by water from an inſect called *cochineal*, or from the root of a plant called *madder*.

399 Do not reflect light.

2. Mr Delaval has publiſhed a very intereſting ſet of experiments on colouring matters in the ſecond volume of the Mancheſter Memoirs. He has proved, by a very numerous ſet of experiments, that they are all tranſparent, and that they do not *reflect* any light, but only tranſmit it: For every colouring matter which he tried, even when diſſolved in a liquid, and forming a tranſparent coloured ſolution, when ſeen merely by reflected light, was black, whatever was the colour of the matter; but when ſeen by tranſmitted light, it appeared of its natural colour *. This diſcovery, which Mr Delaval has eſtabliſhed very completely, and to which, as far at leaſt as dye ſtuffs are concerned, there are but few exceptions, is of very great importance to the art of dyeing, and explains ſeveral particulars which would otherwiſe be unintelligible.

* *Manch. Mem.* ii. 131.

Since the particles of the colouring matter with which cloth, when dyed, is covered, are tranſparent, it follows, that all the light reflected from dyed cloth muſt be reflected, not by the dye ſtuff itſelf, but by the fibres of the cloth below the dye ſtuff. The colour therefore does not depend upon the dye alone, but alſo upon the previous colour of the cloth. If the cloth be *black*, it is clear that we cannot dye it any colour whatever; becauſe as no light in that caſe is reflected, none can be tranſmitted, whatever dye ſtuff we employ. If the cloth were red, or blue, or yellow, we could not dye it any colour except black; becauſe as only red, or blue, or yellow rays were reflected, no other could be tranſmitted (x). Hence the importance of a fine white colour when cloth is to receive bright dyes: It then reflects all the rays in abundance: and therefore any colour may be given, by covering it with a dye ſtuff which tranſmits only ſome particular rays.

400 They muſt be combined with the cloth.

3. If the colouring matters were merely ſpread over the ſurface of the fibre of cloth by the dyer, the colours produced might be very bright, but they could not be permanent; becauſe the colouring matter would be very ſoon rubbed off, and would totally diſappear whenever the cloth was waſhed, or even barely expoſed to the weather. The colouring matter, then, however perfect a colour it poſſeſſes, is of no value, unleſs it alſo adheres ſo firmly to the cloth, that none of the ſubſtances uſually applied to cloth in order to clean it, &c. can diſplace it. Now this can only happen when there is a ſtrong *affinity* between the colouring matter and the cloth, and when they are actually combined together in conſequence of that affinity.

401 Can only be applied in a ſtate of ſolution.

4. Dyeing, then, is merely a chemical proceſs, and conſiſts in combining a certain colouring matter with the fibres of cloth. This proceſs can in no inſtance be performed, unleſs the dye ſtuff be firſt reduced to its integrant particles; for the attraction of aggregation between the particles of dye ſtuffs is too great to be overcome by the affinity between them and cloth, unleſs they could be brought within much ſmaller diſtances than is poſſible, while they both remain in a ſolid form. It is neceſſary, therefore, previouſly to diſſolve the colouring matter in ſome liquid or other, which has a weaker affinity for it than the cloth has. When the cloth is dipped into this ſolution, the colouring matter, reduced by this contrivance to a liquid ſtate, is brought within the attracting diſtance; the cloth therefore acts upon it, and by its ſtronger affinity takes it from the ſolvent, and fixes it upon itſelf. By this contrivance, too, the equality of the colour is in ſome meaſure ſecured, as every part of the cloth has an opportunity of attracting to itſelf the proper proportion of colouring particles.

The facility with which cloth imbibes a dye, depends upon two things, namely, the affinity between the cloth and the dye ſtuff, and the affinity between the dye ſtuff and its ſolvent. It is directly as the former, and inverſely as the latter. It is of importance to preſerve a due proportion between theſe two affinities, as upon that proportion much of the accuracy of dyeing depends. If the affinity between the colouring matter and the cloth be too great, compared with the affinity between the colouring matter and the ſolvent, the cloth will take the dye too rapidly, and it will be ſcarce poſſible to prevent its colour from being unequal. On the other hand, if the affinity between the colouring matter and the ſolvent be too great, compared with that

(x) Theſe remarks hold only on the ſuppoſition, that the *whole* of the ſurface is of the given colour, which in many inſtances is not the caſe.

ing in neral. that between the colouring matter and the cloth, the cloth will either not take the colour at all, or it will take it very ſlowly and very faintly.

Wool has the ſtrongeſt affinity for almoſt all colouring matters, ſilk the next ſtrongeſt, cotton a conſiderably weaker affinity, and linen the weakeſt affinity of all. Therefore, in order to dye cotton or linen, the dye ſtuff ſhould in many caſes be diſſolved in a ſubſtance for which it has a weaker affinity than for the ſolvent employed in the dyeing of wool or ſilk. Thus we may uſe oxide of iron diſſolved in ſulphuric acid, in order to dye wool; but for cotton and linen, it is better to diſſolve it in acetous acid.

2 ure of dants. 5. Were it poſſible to procure a ſufficient number of colouring matters having a ſtrong affinity for cloth, to anſwer all the purpoſes of dyeing, that art would be exceedingly ſimple and eaſy. But this is by no means the caſe: if we except indigo, the dyer is ſcarcely poſſeſſed of a dye ſtuff which yields of itſelf a good colour ſufficiently permanent to deſerve the name of a dye.

This difficulty, which at firſt ſight appears inſurmountable, has been obviated by a very ingenious contrivance. Some ſubſtance is pitched upon which has a ſtrong affinity both for the cloth and the colouring matter. This ſubſtance is previouſly combined with the cloth, which is then dipped into the ſolution containing the dye ſtuff. The dye ſtuff combines with the intermediate ſubſtance; which, being firmly combined with the cloth, ſecures the permanence of the dye. Subſtances employed for this purpoſe are denominated *mordants* (Y).

The moſt important part of dyeing is undoubtedly the proper choice and the proper application of mordants, as upon them the permanence of almoſt every dye depends. Every thing which has been ſaid reſpecting the application of colouring matters, applies equally to the application of mordants. They muſt be previouſly diſſolved in ſome liquid, which has a weaker affinity for them than the cloth has to which they are to be applied; and the cloth muſt be dipped, or even ſteeped, in this ſolution, in order to ſaturate itſelf with the mordant.

Almoſt the only ſubſtances uſed as mordants are, earths, metallic oxides, tan, and oil.

3 y ants. 6. Of earthy mordants, by far the moſt important and moſt generally uſed is alumina. It was uſed as a mordant in very early ages, and ſeems indeed to have been the very firſt ſubſtance employed for that purpoſe. Alumina has a very ſtrong affinity for wool and for ſilk; but its affinity for cotton and linen is a good deal weaker.

It is uſed as a mordant in two ſtates; either in the ſtate of alum, in which it is combined with ſulphuric acid and a little potaſs; or in the ſtate of acetite of alumina, in which it is combined with acetous acid.

Alum was employed as a mordant very early. The ancients, indeed, do not ſeem to have been generally acquainted with pure alum; they uſed it in that ſtate of impurity in which it is found native; of courſe it was uſed in dyeing long before the nature of its ingredients was underſtood, and therefore long before the part which it acts was ſuſpected. Indeed, it is but a very ſhort time ſince the office which mordants perform was ſuſpected: the firſt perſon that hit upon it was Mr Keir; he gave an account of the real uſe of mordants in his tranſlation of Macquer's Dictionary, publiſhed in 1771 *. Dyeing in General.

Alum, when uſed as a mordant, is diſſolved in water, and very frequently a quantity of tartar is diſſolved along with it. Into this ſolution the cloth is put and kept in it till it has abſorbed as much alumina as is neceſſary. It is then taken out, and for the moſt part waſhed and dried. It is now a good deal heavier than it was before, owing to the alumina which has combined with it. The tartar ſerves two purpoſes: the potaſs which it contains combines with the ſulphuric acid of the alum, and thus prevents that very corroſive ſubſtance from injuring the texture of the cloth, which otherwiſe might happen; the tartarous acid, on the other hand, combines with part of the alumina, and forms a tartrite of alumina, which is more eaſily decompoſed by the cloth than alum.

* Macquer, p. 215.

Acetite of alumina has been introduced into dyeing ſince the commencement of the 18th century; and, like many other very important improvements, we are indebted for it to the ignorance of the calico printers, who firſt introduced it. As they did not underſtand the nature nor uſe of the mordants which they employed, they were accuſtomed to mix with their alum an immenſe farrago of ſubſtances, a great proportion of which are injurious inſtead of being of ſervice. Some one or other had mixed with alum acetite of lead: the good effects of this mixture would be ſoon perceived; the quantity of acetite was gradually increaſed, and the other ingredients omitted *. This mordant is now prepared, by pouring acetite of lead into a ſolution of alum: a double decompoſition takes place, the ſulphuric acid combines with the lead, and the compound precipitates in the form of an inſoluble powder; while the alumina combines with the acetous acid, and remains diſſolved in the liquid. This mordant is employed for cotton and linen, which have a weaker affinity than wool for alumina. It anſwers much better than alum, the cloth is more eaſily ſaturated with alumina, and takes, in conſequence, both a richer and a more permanent colour.

* Bancroft, p. 176.

Beſides alumina, *lime* is ſometimes uſed as a mordant. Cloth has a ſtrong enough affinity for it; but in general it does not anſwer ſo well, as it does not give ſo good a colour. When uſed, it is either in the ſtate of lime-water or of ſulphat of lime diſſolved in water.

7. Almoſt all the metallic oxides have an affinity for cloth; but only two of them are extenſively uſed as mordants, namely, the oxides of tin and of iron. 404 Metallic mordants.

The oxide of tin was firſt introduced into dyeing by Kuffer (Z), a German chemiſt, who brought the ſecret to London in 1543. This period forms an era in the hiſtory of dyeing. The oxide of tin has enabled the moderns

4 I 2

(Y) This term, impoſed by the French dyers before the action of mordants was underſtood, ſignifies *biters* or *corroders*. Theſe bodies were ſuppoſed to act merely by corroding the *cloth*. Mr Henry of Mancheſter has propoſed to ſubſtitute the word *baſis* for *mordant*; but that word is too general to anſwer the purpoſe well.

(Z) Mr Delaval has ſuppoſed, that the Tyrians were acquainted with the uſe of tin in dyeing, and Mr Henry

Dyeing in General.

moderns greatly to furpafs the ancients in the finenefs of their colours: by means of it alone, *fcarlet*, the brighteft of all colours, is produced. The method of producing the celebrated purple dye of the ancients is underftood at prefent, and the fhell fifh which yield the dye-ftuff are found abundantly on the coafts of Britain and France; but no perfon thinks now of putting the ancient mode in practice, becaufe infinitely more beautiful colours can be produced at a fmaller price. Much of this fuperiority is owing to the employment of the oxide of tin.

Tin, as Prouft has proved, is capable of two degrees of oxydation: The firft oxide is compofed of 0.70 parts of tin, and 0.30 of oxygen; the fecond, or white oxide, of 0.60 parts of tin, and 0.40 of oxygen *. The firft oxide abforbs oxygen with very great facility even from the air, and is rapidly converted into white oxide. This fact makes it certain, that it is the white oxide of tin alone which is the real mordant: even if the other oxide were applied to cloth, as it probably often is, it muft foon be converted into white oxide, by abforbing oxygen from the atmofphere.

* *Ann. de Chim.* xxviii. 213.

Tin is ufed as a mordant in three ftates; diffolved in nitro muriatic acid, in acetous acid, and in a mixture of fulphuric and muriatic-acids. Nitro-muriat of tin is the common mordant employed by dyers. They prepare it by diffolving tin in diluted nitric acid, to which a certain proportion of muriat of foda, or of ammonia, is added. Part of the nitric acid decompofes thefe falts, combines with their bafe, and fets the muriatic acid at liberty. They prepared it at firft with nitric acid alone; but that mode was very defective; becaufe the nitric acid very readily converts tin to white oxide, and then is incapable of diffolving it. The confequence of which was, the precipitation of the whole of the tin. To remedy this defect, common falt, or fal-ammoniac, was very foon added, muriatic acid having the property of diffolving white oxide of tin very readily. A confiderable faving of nitric acid might be obtained, by employing as much fulphuric acid as is juft fufficient to faturate the bafe of the common falt, or fal-ammoniac, employed.

When the nitro-muriat of tin is to be ufed as a mordant, it is diffolved in a large quantity of water, and the cloth is dipped in the folution, and allowed to remain till fufficiently faturated. It is then taken out, and wafhed and dried. Tartar is ufually diffolved in the water along with the nitro-muriat. The confequence of this is a double decompofition; the nitro muriatic acid combines with the potafs of the tartar, while the tartarous acid diffolves the oxide of tin. When tartar is ufed, therefore, in any confiderable quantity, the mordant is not a nitro-muriat, but a tartrite of tin.

Mr Hauffman, to whom the art of dyeing lies under numerous obligations, has propofed to fubftitute acetite of tin for nitro-muriat as a mordant for cotton and linen. It may be prepared by mixing together acetite of lead and nitro-muriat of tin. This mordant is preferable for thefe ftuffs; becaufe it is much more eafily decompofed than the nitro-muriat †.

† *Ann. de Chim.* xxx. 15.

Dr Bancroft has propofed to fubftitute a folution of tin in a mixture of fulphuric and muriatic acid, inftead of nitrio-muriat of tin, as a mordant for wool. This mordant, he informs us, is much cheaper, and equally efficacious. It may be prepared by diffolving fomewhat lefs than one part of tin in two parts of fulphuric and three of muriatic acid, at the degree of concentration at which they are commonly fold in this country ‡. This mordant, like the others, muft be diffolved in a fufficient quantity of water, in order to be ufed.

‡ *Bancroft* p. 290.

Iron, like tin, is capable of two degrees of oxydation; but the green oxide abforbs oxygen fo readily from the atmofphere, that it is very foon converted into the red oxide. It is only this laft oxide which is really ufed as a mordant in dyeing. The green oxide is indeed fometimes applied to cloth; but it very foon abforbs oxygen, and is converted into the red oxide. This oxide has a very ftrong affinity for all kinds of cloth. The permanency of the iron fpots on linen and cotton is a fufficient proof of this. As a mordant, it is ufed in two ftates; in that of fulphat of iron, and acetite of iron. The firft is commonly ufed for wool. The falt is diffolved in water, and the cloth dipped in it. It may be ufed alfo for cotton; but in moft cafes acetite of iron is preferred. It is prepared by diffolving iron, or its oxide, in vinegar, four beer, &c. and the longer it is kept, the more is it preferred. The reafon is, that this mordant fucceeds beft when the iron is in the ftate of red oxide. It would be better then to oxydate the iron, or convert it into ruft, before ufing it; which might eafily be done, by keeping it for fome time in a moift place, and fprinkling it occafionally with water. Of late, pyrolignous acid has been introduced inftead of acetous. It is obtained by diftilling wood or tar.

405 Tan.

8. Tan, which has been already defcribed in the firft part of this article, has a very ftrong affinity for cloth, and for feveral colouring matters. It is therefore very frequently employed as a mordant. An infufion of *nut galls*, or of *fumach* (A), or any other fubftance containing tan, is made in water, and the cloth is dipped in this infufion, and allowed to remain till it has abforbed a fufficient quantity of tan. Silk is capable of abforbing a very great proportion of tan, and by that means acquires a very great increafe of weight. Manufacturers fometimes employ this method of increafing the weight of filk *.

* *Bertholet*, ii. 10

Tan is often employed alfo, along with other mordants, in order to produce a compound mordant. Oil is alfo ufed for the fame purpofe in the dyeing of cotton and linen. The mordants, with which tan moft frequently is combined, are alumina and oxide of iron.

406 Other mordants.

Befides thefe mordants, there are feveral other fubftances frequently ufed as auxiliaries, either to facilitate the combination of the mordant with the cloth, or to alter

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ry has declared himfelf of the fame opinion. But this reafoning, as Dr Bancroft has fhewn, proceeds upon a miftake. He fuppofes that tin is *neceffary* for the production of red colours.

(A) Sumach is the *rhus coriaria*; a fhrub which is cultivated in the fouthern parts of Europe. Its fhoots are dried, afterwards ground to powder; in which ftate they are fold to the dyer and tanner.

'yeing in General.

alter the ſhade of colour. The chief of theſe are, *tartar, acetite of lead, common ſalt, ſal ammoniac, ſulphat* or *acetite of copper*, &c.

407 ordants ect the our.

9. Mordants not only render the dye permanent, but have alſo conſiderable influence on the colour produced. The ſame colouring matter produces very different dyes, according as the mordant is changed. Suppoſe, for inſtance, that the colouring matter be cochineal; if we uſe the aluminous mordant, the cloth will acquire a crimſon colour; but the oxide of iron produces with it a black. Theſe changes, indeed, might naturally have been expected: for ſince the colour of a dye ſtuff depends upon its affinity for light, every new combination into which it enters, having a tendency to alter theſe affinities, will naturally give it a new colour. Now, in all caſes, the colouring matter and mordant combine together: the colour of the cloth, then, muſt be that which the particles of the dye and of the mordant, when thus combined together, exhibit. Indeed ſome mordants may be conſidered in the light of colouring matters alſo, as they always communicate a particular colour to cloth. Thus, iron communicates a brown colour, and iron and tan together conſtitute a black dye.

In dyeing, then, it is not only neceſſary to procure a mordant, which has a ſufficiently ſtrong affinity for the colouring matter and the cloth, and a colouring matter which poſſeſſes the wiſhed-for colour in perfection, we muſt procure a mordant and a colouring matter of ſuch a nature, that when *combined together* they ſhall poſſeſs the wiſhed-for colour in perfection. It is evident, too, that a great variety of colours may be produced with a ſingle dye-ſtuff, provided we can change the mordant ſufficiently.

408 w applied.

10. Every thing which tends to weaken the affinity between the mordant and the cloth, or between the mordant and the colouring matter, and every thing which tends in any way to alter the nature of the mordant, muſt injure the permanency of the dye: becauſe, whenever the mordant is deſtroyed, there is no longer any thing to cauſe the dye ſtuff to adhere; and when its nature is altered, the colour of the dye muſt alter at the ſame time. All the obſervations, then, which were made in the laſt chapter, concerning the nature of colouring matters, and the changes to which they are ſubject, apply equally to mordants. Theſe ſubſtances, indeed, are ſcarcely liable themſelves to any alteration. They are of a much more ſimple nature, in general, than dye ſtuffs; and therefore not nearly ſo liable to decompoſition. But when the colouring matter itſelf is altered, it comes to the ſame thing. Its affinity for the mordant being now deſtroyed, there is nothing to retain it.

As the permanency of a dye depends upon the degree of affinity between the mordant and the colouring matter, it is clear that the dye may want permanency, even though it reſiſt the oxy muriatic acid, and all the other ſaline teſts propoſed by chemiſts. Theſe ſubſtances may happen to have very little action on the dye-ſtuff, and therefore may not affect it; yet it may ſoon diſappear, in conſequence of its want of affinity for the mordant.

11. The colouring matter with which cloth is dyed, does not cover every portion of its ſurface; its particles attach themſelves to the cloth at certain diſtances from each other: for cloth may be dyed different ſhades of the ſame colour, lighter or darker, merely by varying the quantity of colouring matter. With a ſmall quantity, the ſhade is light; and it becomes deeper as the quantity increaſes. Now this would be impoſſible, if the dye-ſtuff covered the whole of the cloth. Newton has demonſtrated, that colours are rendered faint when the rays of light which occaſion them are mixed with white rays. Conſequently, from cloth dyed of a light ſhade, a conſiderable quantity of white rays paſſes off unchanged: but this could not be the caſe if the ſtuff were covered with coloured matter; becauſe all the white rays would be decompoſed as they paſs through the coloured matter. Therefore, in light ſhades, the colouring matter does not cover the cloth; its particles adhere to it, at a certain diſtance from each other, and from every part of the cloth which is uncovered, the white rays paſs off unchanged. Even when the ſhade of colour is as deep as poſſible, the colouring particles do not cover the whole of the cloth, but are at a certain diſtance from each other. This diſtance, undoubtedly, is diminiſhed in proportion to the deepneſs of the ſhade: for the deeper the ſhade, the ſmaller is the number of white rays which eſcape undecompoſed; the more, therefore, of the ſurface is covered, and, conſequently, the ſmaller is the diſtance at which each each of them is placed. A ſhade may be even conceived ſo very deep, that not a particle of white light eſcapes the action of the colouring matter; in which caſe, the diſtance between the particles of colouring matter could not exceed double that diſtance at which a particle of matter is able to act upon light.

Dyeing in General.

409 Dye ſtuffs do not cover the whole ſurface of the cloth.

410 Compound colours.

That the particles of colouring matter, even when the ſhade is deep, are at ſome diſtance, is evident from this well-known fact, that cloth may be dyed two colours at the ſame time. All thoſe colours, to which the dyers give the name of *compound*, are in fact two different colours applied to the cloth at once. Thus cloth gets a *green* colour, by being firſt dyed *blue* and then *yellow*. The rays of light that paſs from green cloth thus dyed are blue and yellow; by the mixture of which it is well known that green is produced. In this caſe, it is clear, that each of the colouring matters performs the very ſame office as if it were alone; and that the new colour is not produced by the combination of the two colouring matters. That part of the white light, reflected from the cloth, which paſſes through the blue colouring matter, is decompoſed, and the blue rays only tranſmitted; and that part of the white light which paſſes through the yellow colouring matter is alſo decompoſed, and only the yellow rays tranſmitted. It is clear, therefore, that both of the colouring matters equally cover the naked fibres of the cloth; conſequently the one muſt be placed in the intervals of the other: wherefore the particles of each of the colouring matters are at ſome diſtance. Now the ſame effect happens how deep ſoever the ſhade be; and it makes no difference which of the two dyes be firſt given. Nay, if one of the dyes have a ſtrong affinity for the cloth, and the other only a weak affinity, the latter will ſoon diſappear, and leave the cloth of the colour which the firſt dye gives it.

The difference, then, in the ſhade of colour, and alſo the compound colours which cloth may receive, depend entirely upon the diſtance between the particles of the colouring matters attached to the cloth, and the poſſibi-

lity

Blue. lity of partly filling up the intervals, either with the ſame colouring matter, or with a different one.

Thus we have taken a view of the theory of dyeing, as far, at leaſt, as it is at preſent underſtood. It remains for us ſtill to give an account of the particular manner by which each of the colours is imparted to cloth. This ſhall be the ſubject of the three following chapters. In the *firſt*, we ſhall treat of the manner of dyeing the ſimple colours; in the *ſecond*, of dyeing the compound colours; and in the *third*, of dyeing cloth partially ſeveral different colours at the ſame time, or of that branch of the art of dyeing which is known in this country by the name of *calico printing*.

CHAP. IV. OF DYEING SIMPLE COLOURS.

THE colours denominated by dyers *ſimple*, becauſe they are the foundation of all their other proceſſes, are four; namely, *1ſt*, blue;—*2d*, yellow;—*3d*, red;—*4th*, black. To theſe they uſually add a fifth, under the name of *root*, or brown colour. Theſe ſhall form the ſubject of the following ſections.

SECT. I. *Of Blue.*

411 Blue dyes. THE only colouring matters employed in dyeing blue are *woad* and *indigo*: attempts, indeed, have been made to dye with pruſſiat of iron; but theſe attempts have hitherto failed.

412 Woad. 1. The *iſatis tinctoria*, or *woad*, is a plant commonly enough cultivated in this kingdom, and even found wild in ſome parts of England. It is of a yellowiſh colour. Some perſons think that it was this plant with which the ancient Britons ſtained their bodies, to make them appear terrible to their enemies. When arrived at maturity, this plant is cut down, waſhed, dried haſtily in the ſun, ground in a mill, placed in heaps, and allowed to ferment for a fortnight; then well mixed together, formed into balls, which are piled upon each other, and expoſed to the wind and ſun. In this ſtate they gradually become hot, and exhale a putrid ammoniacal ſmell. The fermentation is promoted, if neceſſary, by ſprinkling the balls with water. When it has continued for a ſufficient time, the woad is allowed to fall to a coarſe powder. In this ſtate it is ſold to the dyers.

413 Indigo, 2. Indigo, is a blue coloured powder extracted from the *indigofera tinctoria*, and from ſeveral other ſpecies of the ſame genus of plants, which are cultivated for that purpoſe both in the Eaſt and Weſt Indies.

414 How prepared. When the *indigofera* has arrived at maturity, it is cut a few inches above ground, placed in ſtrata in a large veſſel, and covered with water. The plants ſoon acquire heat, ferment, and diſcharge abundance of carbonic acid gas. When the fermentation is far enough advanced, which is judged of by the paleneſs of the leaves, the liquid, now of a green colour, is decanted into large flat veſſels, where it is conſtantly agitated till blue flocculæ begin to make their appearance. Lime water is now poured in, which cauſes the blue flocks to precipitate. The colourleſs liquid is decanted off, and the blue ſediment poured into linen bags. When the water has drained from it ſufficiently, it is formed into ſmall lumps, and dried in the ſhade. In this ſtate it is ſold to the dyer under the name of *indigo*.

Dr Roxbourgh, who firſt drew the attention of manufacturers to the *nerium tinctorium*, a tree very common in Indoſtan, from the leaves of which indigo may be extracted with much advantage, has given a much ſhorter method of obtaining that pigment. The leaves are kept in a copper full of water, ſupported at the temperature of 160°, till they aſſume a yellowiſh hue, and the liquid acquire a deep green colour. The liquid is then to be drawn off, agitated in the uſual manner, till the blue flocculæ appear; and then the indigo is to be precipitated with lime water *. * Bancroft i. 423.

This proceſs, which ſucceeds equally well with the indigofera, ſhews us that the plants, from which indigo may be extracted, contain a peculiar green pollen, ſoluble in water. The intention, both of the fermentation of the common method, and of the ſcalding, according to Dr Roxbourgh's method, is merely to extract this pollen. Mr Hauſſman firſt ſhewed, that this green baſis of indigo has a ſtrong affinity for oxyen; and the ſubſequent experiments of Drs Roxbourgh and Bancroft have confirmed his obſervations, and put them beyond the reach of doubt. It gradually attracts oxygen from the air; in conſequence of which it acquires a blue colour, and becomes inſoluble in water. The agitation is intended to facilitate this abſorption, by expoſing a greater ſurface to the action of the air. The lime water, by abſorbing a quantity of carbonic acid, with which the green pollen ſeems to be combined, greatly facilitates the ſeparation of the indigo.

The method of preparing indigo, and of applying it to the purpoſes of dyeing, ſeems to have been very early known in India. But in Europe, though it had been occaſionally uſed as a paint *, its importance as a dye ſtuff was not underſtood before the middle of the 16th century. It is not even mentioned in the *Plictho*, which was publiſhed in 1548. At that period, then, the uſe of indigo muſt have been unknown to the Italian dyers. The Dutch were the people who firſt imported it from India, and made its importance known in Europe. It was afterwards cultivated in Mexico and the Weſt Indies with ſuch ſucceſs, that the indigo from theſe countries was preferred to every other. In conſequence of this preference, they ſupplied almoſt the whole of the European market. But within theſe few years, the Eaſt Indian indigo, owing entirely to the enlightened exertions of ſome of our own countrymen, has recovered its character, and is now imported, in very conſiderable quantities, into Britain. * Plinii, l. 35. c. 6.

The indigo of commerce has different ſhades of colour, according to the manner in which it has been prepared, and the proportion of foreign ſubſtances with which it is mixed. The principal ſhades are copper colour, violet, and blue. That indigo, which has the ſmalleſt ſpecific gravity, is always moſt eſteemed; becauſe it is moſt free from impurities. Bergman † found the pureſt indigo of commerce which he could procure, compoſed of † Berg. v. 36.

47	pure indigo,
12	gum,
6	reſin,
22	earth,
13	oxide of iron.
100 (B)	

Pure

(B) Prouſt informs us, that he found magneſia, even abundantly, in indigo.—*Nicholſon's Jour.* III. 325.

Blue.

415 Proper-ties. Pure indigo is inſoluble in water, alcohol, æther, and oils: neither alkalies nor earths have any action on it: none of the acids hitherto tried have any effect on it, except the nitric and ſulphuric. Nitric acid very ſoon converts it into a dirty white colour, and at laſt decompoſes it completely *. When the acid is concentrated, it even ſets fire to the indigo (c); when it is diluted, the indigo becomes brown, cryſtals make their appearance, reſembling thoſe of oxalic and tartarous acids: and there remains behind, after the acid and the cryſtals are waſhed off, a viſcid ſubſtance, of a very bitter taſte, and poſſeſſing many of the properties of a reſin †.

erg. v.

Hauſſman.

Concentrated ſulphuric acid diſſolves indigo readily, and much heat is evolved. The ſaturated ſolution is opaque, and conſequently black; but it aſſumes a deep blue colour when diluted with water. This ſolution is well known in commerce under the name of *liquid blue*. Bancroft has given it the name of *ſulphat of indigo*. During the ſolution of the indigo, ſome ſulphurous acid, and ſome hydrogen gas, are evolved ‡, and the blue colour of the indigo is much heightened. Theſe facts have led Bancroft to ſuppoſe, that the indigo, during its ſolution, combines with an additional quantity of oxygen *. This *may* poſſibly be the caſe, but the phenomena are not ſufficient to eſtabliſh it: for the hydrogen gas and ſulphurous acid evolved may owe their formation, not to the action of the ſulphuric acid on indigo, but upon the impurities with which it is always mixed; and the improvement of the colour may be owing to the abſence of theſe impurities. The carbonats of fixed alkalies precipitate ſlowly from ſulphat of indigo a blue coloured powder, which poſſeſſes the properties of indigo; but it is ſoluble in moſt acids and in alkalies. Pure alkalies deſtroy the colour and properties of ſulphat of indigo: they deſtroy alſo precipitated indigo §. Theſe facts give ſome probability to Bancroft's opinion; but they do not eſtabliſh it: becauſe the differences between common and precipitated indigo may depend merely on the ſtate of greater minuteneſs to which it is reduced, which prevents the attraction of aggregation from obſtructing the action of other bodies. Even ſilica, when newly precipitated, is ſoluble in many menſtrua.

Bancroft, &c. — rg v.

416 Method of dyeing with ſulphat of indigo. 3. Indigo has a very ſtrong affinity for wool, ſilk, cotton, and linen. Every kind of cloth, therefore, may by dyed with it, without the aſſiſtance of any mordant whatever. The colour thus indeed is very permanent; becauſe the indigo is already ſaturated with oxygen, and becauſe it is not liable to be decompoſed by thoſe ſubſtances, to the action of which the cloth is expoſed. But it can only be applied to cloth in a ſtate of ſolution; and the only ſolvent known being ſulphuric acid, it would ſeem at firſt ſight that the ſulphuric acid ſolution is the only ſtate in which indigo can be employed as a dye.

The ſulphat of indigo is indeed often uſed to dye wool and ſilk blue; but it can ſcarcely be applied to cotton and linen, becauſe the affinity of theſe ſubſtances for indigo is not great enough to enable them readily to decompoſe the ſulphat. The colour given by ſulphat of indigo is exceedingly beautiful: it is known by the name of Saxon blue; becauſe the proceſs, which was diſcovered by councellor Barth in 1740, was firſt carried on at Groſſenhayn in Saxony. The method of the original inventor was very complicated, from the great number of uſeleſs ingredients which were mixed with the ſulphat. But theſe ingredients were gradually laid aſide, and the compoſition ſimplified by others, after the nature of it, which was for ſome time kept ſecret, became known to the public. The beſt proceſs is that of Mr Poerner *.

One part of indigo is to be diſſolved in four parts of concentrated ſulphuric acid; to the ſolution one part of dry carbonat of potaſs is to be added, and then it is to be diluted with eight times its weight of water. The cloth muſt be boiled for an hour in a ſolution, containing five parts of alum and three of tartar for every 32 parts of cloth. It is then to be thrown into a water bath, containing a greater or ſmaller proportion of the diluted ſulphat of indigo, according to the ſhade which the cloth is intended to receive. In this bath it muſt be boiled till it has acquired the wiſhed for colour. The alum and tartar are not intended to act as mordants, but to facilitate the decompoſition of the ſulphat of indigo. Bergman aſcertained that alum poſſeſſes this property. The alkali added to the ſulphat anſwers the ſame purpoſe. Theſe ſubſtances, alſo, by ſaturating part of the ſulphuric acid, ſerve, in ſome meaſure, to prevent the texture of the cloth from being injured by the action of the acid, which is very apt to happen in this proceſs.

* *Instruction ſur l'Art de la Teinture*, p. 183.

417 Method of dyeing by decompoſing indigo.

4. But ſulphat of indigo is by no means the only ſolution of that pigment employed in dyeing. By far the moſt common method, and indeed the only method known before 1740, is to deprive indigo of the oxygen to which it owes its blue colour, and thus to reduce it to the ſtate of green pollen; and then to diſſolve it in water by means of alkalies, or alkaline earths, which in that ſtate act upon it very readily. Indigo is preciſely in the ſtate of green pollen when it is firſt extracted from the plant in the ſcalding proceſs deſcribed by Dr Roxbourgh. If, therefore, there were any method of ſtopping ſhort here, and of ſeparating the pigment while it retains its green colour, it would be preciſely in the ſtate beſt adapted for dyeing. Nothing more would be neceſſary but to diſſolve it in water by means of an alkali, and to dip the cloth into the ſolution †.

† Bancroft.

But as indigo is not brought home to us in that ſtate, the dyer is under the neceſſity of undoing the laſt part of the indgo-maker's proceſs, by ſeparating again the oxygen, and reſtoring it to its original green colour. Two different methods are employed for this purpoſe. The firſt of theſe methods is to mix with indigo a ſolution of ſome ſubſtance which has a ſtronger affinity for oxygen than the green baſis of indigo. Green oxide of iron, for inſtance, and different metallic ſulphurets. If, therefore, indigo, lime, and green ſulphat of iron, be mixed together in water, the indigo gradually

(c) The combuſtion of indigo by nitric acid, of the denſity 1.52°, was firſt publiſhed by Mr Sage; but Woulfe appears to have obſerved the fact before him, and to have pointed it out to Rouelle, who ſhewed it in his lectures. *Prouſt, Nicholſon's Jour.* III. 325.

Blue

gradually loses its blue colour, becomes green, and is dissolved, while the green oxide of iron is converted into the red oxide. The manner in which these changes take place is obvious. Part of the lime decomposes the sulphat of iron; the green oxide, the instant that it is set at liberty, attracts oxygen from the indigo, decomposes it, and reduces it to the state of green pollen. This green pollen is immediately dissolved by the action of the rest of the lime. In like manner, indigo is dissolved when mixed in water, with pure antimony and potass, or with sulphuret of arsenic and potass. For these interesting facts we are indebted to Mr Hausmann.

The second method is to mix the indigo in water with certain vegetable substances which readily undergo fermentation. During this fermentation, the indigo is deprived of its oxygen, and dissolved by means of quicklime or alkali, which is added to the solution. The first of these methods is usually followed in dyeing cotton and linen; the second in dyeing wool and silk.

418 How to induce a blue colour on wool,

5. In the dyeing of wool, woad and bran are commonly employed as vegetable ferments, and lime as the solvent of the green base of the indigo. Woad contains itself a colouring matter precisely similar to indigo; by following the common process, indigo may be extracted from it. In the usual state of woad, when purchased by the dyer, the indigo which it contains is probably not far from the state of green pollen. Its quantity in woad is but small, and it is mixed with a great proportion of other vegetable matter. Before the introduction of indigo into Europe, woad alone was employed as a blue dye; and even as late as the 17th century, the use of indigo was restricted in different countries, and dyers obliged to employ a certain quantity of woad (D). But these absurd restrictions were at last removed, and woad is now scarcely used in dyeing, except as a ferment to indigo. The blue colouring matter, however, which it contains, must, in all cases, contribute considerably to the dye.

A sufficient quantity of woad, mixed with bran, is put into a wooden vessel filled with warm water, whose temperature is kept up sufficiently to ensure fermentation. Afterwards quicklime and indigo are added. The indigo is deprived of its oxygen, and dissolved by the lime. When the solution is complete, the liquid has a green colour, except at the surface, where it is copper coloured, or blue, because the indigo at the surface absorbs oxygen from the air, and assumes its natural colour. The woollen cloth is dipped in, and passed thro' the liquid as equably as possible, piece after piece; those pieces being first dyed which are to assume the deepest shade. No part of the cloth should come in contact with the sediment, which would spoil the colour. When the cloth is first taken out of the vat, it is of a green colour; but it soon becomes blue, by attracting oxygen from the air. It ought to be carefully washed, to carry off the uncombined particles. This solution of indigo is liable to two inconveniences: 1. It is apt sometimes to run too fast into the putrid fermentation: this may be known by the putrid vapours which it exhales, and by the disappearing of the green colour. In this state it would soon destroy the indigo altogether. The inconvenience is remedied by adding more lime, which has the property of moderating the putrescent tendency. 2. Sometimes the fermentation goes on too languidly. This defect is remedied by adding more bran or woad, in order to diminish the proportion of quicklime.

6. Silk is usually dyed blue by the following process: Six parts of bran, and six of indigo, with nearly one part of madder, are stirred into a sufficient quantity of water, in which six parts of common potash of commerce is dissolved. The liquid is kept at a temperature proper for fermentation. When the indigo, deprived of its oxygen by the fermentation, is dissolved by the potass, the liquid assumes a green colour. The silk, previously well scoured, is put into the solution in small quantities at a time; then wrung out of the dye, and hung up in the open air, till the green colour which it has at first is changed into blue. By this method silk can only be made to receive a light blue colour. In order to give silk a dark blue, it must previously receive what is called a ground colour; that is, be previously dyed some other colour. A particular kind of red dye-stuff, called *archil* (E), is commonly employed for this purpose. 419 Silk,

The madder employed in the above process may, at first sight, appear superfluous: it seems, however, to contribute something to the colour.

420 Cotton, linen,

7. Cotton and linen are dyed blue by the following process: One part of indigo, one part of green sulphat of iron, and two parts of quicklime, are stirred into a sufficient quantity of water. The solution is at first green, but it gradually assumes a yellow colour, and its surface is covered with a shining copper-coloured pellicle. The cloth is to be allowed to remain in the solution for five or six minutes. When taken out, it has a yellow colour; but on exposure to the atmosphere, it soon becomes green, and then blue, in consequence of the absorption of oxygen. The indigo, in this process, seems to be deprived of a greater quantity of oxygen than is necessary to reduce it to the state of green pollen. Mr Hausman has observed, that the cloth acquires a much deeper colour, provided it be plunged, the instant it is taken out of the dyeing vat, into water acidulated with sulphuric acid. It is usual to dip the cloth into a succession of vats, variously charged with colouring matter; beginning with the vat which contains least colouring matter, and passing gradually to those which contain most. By this contrivance the cloth is dyed more equally than it probably would be, if it were plunged all at once into a saturated solution of colouring matter.

SECT. II. *Of Yellow.*

421 Yellow dyes.

THE principal colouring matters employed to dye yellow are *weld*, *fustic*, and *quercitron bark*.

1. Reseda luteola, known in this country by the name of

(D) The employment of Indigo was strictly prohibited in England in the reign of Queen Elizabeth; nor was the prohibition taken off till the reign of Charles II. It was prohibited also in Saxony. In the edict it is spoken of as a corrosive substance, and called *food for the devil*. Colbert restricted the French dyers to a certain quantity of it.

(E) This will be described in a subsequent section.

Yellow.

of *weld*, is a plant which grows wild very commonly in Scotland, and in moft European countries. Cultivated
422 Weld. weld has a more flender ftem than the wild kind, but it is more valuable, becaufe it is much more rich in colouring matter. It is an annual plant, of a yellowifh green colour, furnifhed with a great number of fmall leaves. When ripe it is pulled, dried, tied up in parcels, and in that ftate fold to the dyer.

Weld readily yields its colouring matter to water. The faturated decoction of it is brown; but when fufficiently diluted with water it becomes yellow. Acids render its colour fomewhat paler, but alkalies give it a deeper fhade. When alum is added to it, a yellow coloured precipitate falls down, confifting of alumina combined with the colouring matter of weld. The affinity therefore of this colouring matter for alumina is fo great, that it is able to abftract it from fulphuric acid. Its affinity for oxide of tin is at leaft equally great; for muriat of tin caufes a copious bright yellow precipitate, compofed of the colouring matter and the oxide combined. Moft of the metallic falts occafion fimilar precipitates, but varying in colour according to the metal employed. With iron, for inftance, the precipitate is drak grey, and with copper brownifh green *.

* Berthollet, ii. 260.

423 Fustic. 2. The *morus tinctoria* is a large tree which grows in the Weft India iflands. The wood of this tree is of a yellow colour, with orange veins. The French call it *yellow wood* (*bois jaune*); but the Englifh dyers have given it the abfurd name of *old fuftic* (F). This wood has been introduced into dyeing fince the difcovery of America. The precife time is not known; but that it was ufed in England foon after the middle of the 17th century, is evident from Sir William Petty's paper on *Dyeing*, read to the Royal Society foon after its inftitution. In that paper particular mention is made of *old fuftic*.

Fuftic gives out its colouring matter with great facility to water. The faturated decoction of it is of a deep reddifh yellow colour; when fufficiently diluted it becomes orange yellow. Acids render it turbid, give it a pale yellow colour, and occafion a flight greenifh precipitate, which alkalies rediffolve. Alkalies give the decoction a very deep colour, inclining to red; fome time after they have been added, a yellow matter feparates from the liquid, and either fwims on the furface, or adheres to the fides of the veffel. Alum, fulphat of iron, of copper, and of zinc, produce precipitates compofed of the colouring matter combined refpectively with the bafes of thefe different falts; and the colour varies according to the fubftance with which this colouring matter is combined. With alumina it is yellow; with iron, yellowifh brown; with copper, brownifh yellow; and with zinc, greenifh brown †.

† [Bancroft,] ii.

424 Quercitron. 3. The *quercus nigra*, to which Dr Bancroft has given the name of *quercitron*, is a large tree which grows naturally in North America. Dr Bancroft difcovered, about the year 1784, that the bark of this tree contains a great quantity of yellow colouring matter, and fince that time it has been introduced into dyeing with much advantage. To prepare it for the dyer, the epidermis is fhaved off, and then it is ground in a mill. It feparates partly into ftringy filaments, and partly into a fine light powder. Both of thefe contain colouring matter, and therefore are to be employed; but as they contain unequal quantities, they fhould be ufed in their natural proportions.

Quercitron bark readily gives out its colouring matter to water at the temperature of 100°. The infufion has a yellowifh brown colour, which is rendered lighter by acids, and darker by alkalies. Alum occafions a fcanty precipitate of a deep yellow colour; muriat of tin, a copious bright yellow precipitate; fulphat of tin, a dark olive precipitate; and fulphat of copper, a precipitate of a yellow colour inclining to olive ‡.

‡ Bancroft, i. 320.

425 Other yellow dyes. 4. Befides thefe dye ftuffs there are others occafionally ufed by dyers. The following are the moft remarkable:

Geniſta tinctoria, or *dyers broom*. This plant yields a very inferior yellow; it is only ufed for coarfe woollen ftuffs.

Serratula tinctoria, or *faw-wort*. This plant yields a yellow nearly of the fame nature with *weld*; for which, therefore, it is a good fubftitute.

Juglans alba, or *American hiccory*. The bark of this tree yields a colouring matter exactly fimilar to that of quercitron bark, but much fmaller in quantity.

Anotta is a name given to a red pafte formed of the berries of the bixa orellana, a tree which is a native of America. This pafte yields its colouring matter to a folution of alkali in water. The folution affords an exceedingly beautiful yellow dye, but very fading, and incapable of being fixed by any known mordant.

Turmeric is the root of the *curcuma longa*, a plant which grows both in the Eaft and Weft Indies. It is richer in colouring mater than any other yellow dye ftuff. It yields very beautiful yellows, but too fading to be of much ufe, and no mordant has any influence in contributing to their permanence.

426 Yellow requires a mordant. 5. Yellow colouring matters have too weak an affinity for cloth to produce permanent colours without the ufe of mordants. Cloth, therefore, before it be dyed yellow, is always prepared by combining fome mordant or other with it. The mordant moft commonly employed for this purpofe is alumina. Oxide of tin is fometimes ufed when very fine yellows are wanted. Tan is often employed as a fubfidiary to alumina, in order to fix it more copioufly on cotton and linen. Tartar is alfo ufed as an auxiliary to brighten the colour; and muriat of foda, fulphat of lime, and even fulphat of iron, in order to render the fhade deeper.

6. The yellow dyed by means of fuftic is more permanent, but not fo beautiful as that given by weld or quercitron. As it is permanent, and not much injured by acids, it is often ufed in dyeing compound colours where

(F) The *rhus cotinus*, or Venice fumach, is a fmall fhrub, formerly employed as a yellow dye, but now almoft out of ufe. The French call it *fuftet*, from which word it is probable, as Dr Bancroft fuppofes, that our dyers formed the term *fuftic*. When the *morus tinctoria* was introduced as a dye-ftuff, they gave it the fame name: but in order to diftinguifh the two, they called the fumach, which was a fmall fhrub, *young fuftic*; and the morus, which was a large tree, *old fuftic*. See *Bancroft*, i. 412.

Yellow.

where a yellow is required. The mordant is alumina. When the mordant is oxide of iron, fustic dyes a good permanent drab colour.

Weld and quercitron bark yield nearly the same kind of colour; but as the bark yields colouring matter in much greater abundance, it is much more convenient, and, upon the whole, cheaper than weld. It is probable therefore, that it will gradually supersede the use of that plant. The method of using each of these dye

427 stuffs is nearly the same.

Method of inducing a yellow colour on wool,

7. Wool may be dyed yellow by the following process: Let it be boiled for an hour, or more, with about $\frac{1}{5}$th of its weight of alum, dissolved in a sufficient quantity of water. It is then to be plunged, without being rinced, into a bath of warm water, containing in it as much quercitron bark as equals the weight of the alum employed as a mordant. The cloth is to be turned through the boiling liquid till it has acquired the intended colour. Then a quantity of clean powdered chalk, equal to the hundredth part of the weight of the cloth, is to be stirred in, and the operation of dyeing continued for eight or ten minutes longer. By this method a pretty deep and lively yellow may be given fully as permanent as weld yellow *.

* Bancroft, i, 352.

For very bright *orange*, or *golden yellows*, it is necessary to have recourse to the oxide of tin as a mordant. A fine orange yellow may be given to woollen cloth, by putting, for every ten parts of cloth, one part of bark into a sufficient quantity of hot water; after a few minutes, an equal weight of murio-sulphat of tin is to be added, and the mixture well stirred. The cloth acquires the wished-for colour in a few minutes when briskly turned in this bath †.

† Ibid. 329.

The same process will serve for producing *bright golden yellows*, only some alum must be added along with the tin. For the brightest golden yellow, the proportions sufficient for dyeing 100 parts of cloth are, 10 parts of bark, 7 parts of murio-sulphat of tin, and 5 parts of alum. All the possible shades of golden yellow may be given to cloth merely by varying the proportion of the ingredients according to the shade ‡.

‡ Ibid. 330.

In order to give the yellow that delicate *green* shade so much admired for certain purposes, the same process may be followed, only tartar must be added in different proportions according to the shade. Thus to dye 100 parts of cloth a *full bright yellow*, delicately inclining to *green*, 8 parts of bark, 6 of murio-sulphat, 6 of alum, and 4 of tartar, are to be employed. The tartar is to be added at the same time with the other mordants. If the proportion of alum and tartar be increased, the green shade is more lively: to render it as lively as possible, all the four ingredients ought to be employed in equal proportions. As these fine lemon-yellows are generally required only pale, 10 parts of each of the ingredients will be sufficient to dye about 300 parts of cloth §.

§ Ibid.

By adding a small proportion of cochineal, the colour may be raised to a fine orange, or even an aurora ‖.

‖ Ibid. 335.

428 Silk,

8. Silk may be dyed different shades of yellow, either by weld or quercitron bark, but the last is the cheapest of the two. The proportion should be from 1 to 2 parts of bark to 12 parts of silk, according to the shade. The bark, tied up in a bag, should be put into the dyeing vessel while the water which it contains is cold, and when it has acquired the heat of about 100°, the silk, previously alumed, should be dipped in, and continued till it assumes the wished-for colour. When the shade required is deep, a little chalk or pearlash should be added towards the end of the operation. When a very lively yellow is wanted, a little murio-sulphat of tin should be added, but not too much, because tin always injures the glossiness of silk. The proportions may be 4 parts of bark, 3 of alum, and 2 of murio-sulphat of tin ¶.

¶ Bancroft, i. 345.

Silk is dyed fine orange and aurora colours by anotta. The process is merely dipping the silk into an alkaline solution of anotta. To produce the orange shade the alkali is saturated with lemon juice. The colours thus produced are exceedingly beautiful, but they want permanency.

429 Cotton, and linen.

9. The common method of dyeing cotton and linen yellow, has been described in the article DYEING in the *Encyclopædia*. The cloth is first soaked in a solution of alum, and then dyed in a decoction of weld. After this it is soaked for an hour in a solution of sulphat of copper, and, lastly, it is boiled for an hour in a solution of hard soap. This process, besides the expence of it, is defective; because the yellow is neither so beautiful nor so permanent as it might be if the mordant were used in a different form.

The method recommended by Dr Bancroft is much more advantageous, yielding more permanent and beautiful colours at a smaller expence. The mordant should be acetite of alumina, prepared by dissolving 1 part of acetite of lead, and 3 parts of alum, in a sufficient quantity of water. This solution should be heated to the temperature of 100°, the cloth should be soaked in it for two hours, then wrung out and dried. The soaking may be repeated, and the cloth again dried as before. It is then to be barely wetted with lime water, and afterwards dried. The soaking in the acetite of alumina may be again repeated; and if the shade of yellow is required to be very bright and durable, the alternate wetting with lime water, and soaking in the mordant, may be repeated three or four times. By this contrivance a sufficient quantity of alumina is combined with the cloth, and the combination is rendered more permanent by the addition of some lime. The dyeing bath is prepared by putting 12 or 18 parts of quercitron bark (according to the depth of the shade required), tied up in a bag, into a sufficient quantity of cold water. Into this bath the cloth is to be put, and turned round in it for an hour, while its temperature is gradually raised to about 120°. It is then to be brought to a boiling heat, and the cloth allowed to remain in it after that only a few minutes. If it be kept long at a boiling heat the yellow acquires a shade of brown *.

* Ibid. 351.

Another way of dyeing cotton and linen very permanent yellows, would be to imitate the method adopted for dyeing cotton in the East. That method is indeed exceedingly tedious, but it might be very much shortened by carefully attending to the uses of the ingredients. The essential part of the process is to cause the alumina to combine in sufficient quantity with the cloth, and to adhere with sufficient firmness to ensure a permanent colour. This is accomplished by using three mordants; first oil, then tan, and lastly alum. The combination of these three substances produces a mordant which ensures a very permanent colour.

The cotton is first soaked in a bath composed of a sufficient quantity of oil, and mixed with a weak solution

Yellow. tion of soda. Animal oil seems to answer best for the purpose. Vogler found that glue answered extremely well. The soda should be caustic: In that state it combines with the oil, and enables the cloth to absorb it equally. It is then, after being washed, put into an infusion of nut galls (the whiter the better). The tan combines with the oil, while the gallic acid carries off the alkali that may remain attached to the cloth The infusion ought to be hot; and the cotton, after coming out of it, should be dried as quickly as possible Care should be taken that the quantity of galls do not exceed a just proportion compared with the oil, otherwise the colour will be darkened. The cotton, thus prepared, is to be put into a solution of alum. There is a strong affinity between tan and alumina; in consequence of which, the alum is decomposed, and the alumina combines with the tan in sufficient abundance †. The cotton, thus prepared, is to be dyed, as above described, with quercitron bark.

† *Chaptal, Ann. de Chim.* xxvi. 251.

430 Chaptal's process for cotton.

Mr Chaptal, whose ingenious labours have contributed exceedingly to elucidate the theory of dyeing, has proposed an exceedingly simple and cheap method of dyeing cotton a fine permanent nankeen yellow. His process is as follows (G).

Cotton has so strong an affinity for oxide of iron, that if put into a solution of that oxide in any acid whatever, it decomposes the salt, absorbs the iron, and acquires a yellow colour. The cotton to be dyed is to be put into a cold solution of sulphat of iron, of the sp. gr. 1.020; it is then wrung out, and put directly into a ley of potass, of the sp. gr. 1.010, into which a solution of alum has been poured till it was saturated with it. After the cotton has remained in this bath four or five hours, it may be taken out, washed, and dried. By this process cotton may be dyed all the different shades of nankeen, by varing the proportion of the sulphat of iron. This colour has the advantage of not being injured by washing, and of being exceedingly cheap §.

§ *Ibid.* 270.

SECT. III. *Of* RED.

431 Red dyes.

THE principal colouring matters employed in dyeing *red* are, *kermes*, *cochineal*, *archil*, *madder*, *carthamus*, and *Brazil wood*.

432 Kermes,

1. In different parts of Asia and the south of Europe, there grows a small species of oak, to which Linnæus gives the name of *quercus coccifera*. On this oak resides a small insect, of a reddish brown colour; in commerce it is known by the name of *kermes*. This insect is a species of *coccus*: Linnæus called it *coccus ilicis*. These insects are gathered in the month of June when the female, which alone is useful, is swelled with eggs. They are steeped for ten or twelve hours in vinegar to kill the young insects contained in the eggs, and afterwards dried on a linen cloth. In this state they are sold to the dyer.

Kermes readily gives out its colouring matter to water or alcohol. It was much used by the ancients in dyeing; the colours which it produced were highly esteemed, being inferior in price only to their celebrated purple. They gave it the name of *coccus*.

The colour which it communicates to cloth is exceedingly permanent, but being far inferior in beauty to those which may be obtained from cochineal, it has been but little employed by dyers since that splendid pigment came into common use. Red.

433 Cochineal,

2. Cochineal is likewise an insect, a species of *coccus*. Linnæus distinguishes it by the name of *coccus cacti*. It inhabits different species of cacti, but the most perfect variety is confined to the *cactus coccinillifer*. The cochineal insect was first discovered in Mexico; the natives had employed it in their red dyes before the arrival of the Spaniards. It became known in Europe soon after the conquest of Mexico; and the beauty of the colour which it communicates to cloth very soon attracted general attention For many years it was mistaken for a vegetable production, as had been the case also with the kermes. Different accounts of its real nature had indeed appeared very early in the Philosophical Transactions; but the opinion of Pomet, who insisted that it was the seed of a particular plant, gained so much credit, that it was not entirely destroyed till the publication of Mr Ellis's paper in the 52d volume of the Philosophical Transactions, which established the contrary beyond the possibility of doubt.

The female cochineal insect remains like the kermes, during her whole life adhering to a particular spot of the tree on which it feeds. After fecundation, her body serves merely as a nidus for her numerous eggs, and gradually swells as these advance towards maturity. In this state the insects are gathered, put into a linen bag, which is dipt into hot water to destroy the life of the young animals contained in the eggs, and then dried. In this state they are sent to Europe and sold to the dyer.

The quantity of cochineal disposed of in Europe is very great. Bancroft informs us, that the Spaniards annually bring to market about 600,000 lbs. of it. Hitherto the rearing of the insects has belonged almost exclusively to that nation. Other nations have indeed attempted to share it with them, but without any remarkable success; as the Spaniards use every precaution to confine the true cochineal, and even the species of cactus on which it feeds, to Mexico. Mr Thiery de Menonville was fortunate enough to procure some specimens of both, and to transfer them in safety to St Domingo; but after his death, the insects were allowed to perish. The wild cochineal insect, which differs from the cultivated kind merely in being smaller, and containing less colouring matter, was produced in St Domingo, in considerable quantities, before the commencement of the late war. Several spirited British gentlemen have lately contrived to procure the insect; and vigorous efforts are making to rear it in the East Indies. We have not yet learned the success of these attempts; but we have reason to hope every thing from the zeal and abilities of those gentlemen who have taken an active part in the enterprize.

Cochineal readily gives out its colouring matter to water. The decoction is of a crimson colour, inclining to violet: It may be kept for a long time without putrefying or losing its transparency. Sulphuric acid gives

(G) We ought to menton, that this process, or at least one very similar, has been long well known to the calico printers of this country. Most of their brown yellows, or drabs, are dyed with iron.

Red.

gives it a red colour, inclining to yellow, and occasions a small fine red precipitate. Tartar gives it a yellowish red colour, which becomes yellow after a small quantity of red powder has subsided. Alum brightens the colour of the decoction, and occasions a crimson precipitate. Muriat of tin gives a copious fine red precipitate; sulphat of iron, a brownish violet precipitate; sulphat of zinc, a deep violate precipitate; acetite of lead, and sulphat of copper, violet precipitates †.

† Berthollet, ii. 173.

Water is not capable of extracting the whole of the colouring matter of cochineal; but the addition of a little alkali or tartar enables the water to extract the whole of it *.

* Ibid. 175. and Bancroft, i. 271.

434 Archil,

3. Archil (H) is a paste formed of the *lichen roccella*, pounded and kept moist for some time with stale urine. It gives out its colouring matter to water, to alcohol (I), and to a solution of ammonia in water.

The lichen roccella grows abundantly in the Canary islands, from which it is imported and sold to the dyers. Other lichens are likewise used to dye red, especially the *parellus*, from which the pigment called *litmus*, and by chemists *turfole*, is prepared; the *omphalodes* and *tartareous*, which are often employed in this country to dye coarse cloths. To these many others might be added; but the reader may consult the treatises of Hoffman and Westring on the subject.

435 Madder,

4. The *rubia tinctorum* is a small well known plant, cultivated in different parts of Europe for the sake of its roots, which are known by the name of *madder*. They are about the thickness of a goose quill, somewhat transparent, of a reddish colour, and a strong smell. They are dried, cleaned, ground in a mill, and in that state used by dyers.

Madder gives out its colouring matter to water. The infusion is of a brownish orange-colour; alum produces in it a deep brownish red precipitate; alkaline carbonats, a blood red precipitate, which is redissolved on adding more alkali. The precipitate occasioned by acetite of lead is brownish red; by nitrat of mercury, purplish brown; by sulphat of iron, a fine bright brown. After the red colouring matter has been extracted from madder by water, it is still capable of yielding a brown colour ‡.

‡ Berthollet, ii. 115.

436 Carthamus.

5. *Carthamus tinctorious* is an annual plant, cultivated in Spain, Egypt, and the Levant, for the sake of its flowers, which alone are used in dyeing. After the juice has been squeezed out of these flowers, they are washed repeatedly with salt water, pressed between the hands, and spread on mats to dry. Care is taken to cover them from the sun during the day, and to expose them to the evening dews, in order to prevent them from drying too fast. Such is the method followed in Egypt.

The flowers of carthamus contain two colouring matters; a yellow, which is soluble in water, and a red, insoluble in water, but soluble in alkaline carbonats. The method of preparing them above described, is intended to carry off the yellow colouring matter, which is of no use, and to leave only the red. After the flowers are thus prepared, they are of a red colour, and have lost nearly one-half of their weight. An alkaline ley readily extracts their colouring matter, which may be precipitated by saturating the alkali with an acid. Lemon juice is commonly used for this purpose, because it does not injure the colour of the dye. Next to citric, sulphuric acid is to be preferred, provided too great a quantity be not used. The red colouring matter of carthamus, extracted by carbonat of soda, and precipitated by lemon juice, constitutes the *rouge* employed by the ladies as a paint. It is afterwards ground with a certain quantity of talc. The fineness of the talc, and the proportion of it mixed with the carthamus, occasion the difference between the cheaper and dearer kinds of *rouge*.

6. *Brazil wood*, or *fernambouc*, as it is called by the French, is the wood of the *cæsalpinia crista*, a tree which grows naturally in America and the West Indian islands. It is very hard; its specific gravity is greater than that of water; its taste is sweetish: its colour, when fresh cut, is pale; but after exposure to the atmosphere, it becomes reddish. 437 Brazil wood.

Brazil wood yields its colouring matter to alcohol, and likewise to boiling water. The decoction is of a fine red colour. The mineral acids make it yellow, and occasion a reddish brown precipitate. Oxalic acid causes an orange red precipitate. Fixed alkali gives the decoction a crimson colour, inclining to brown; ammonia, bright purple. Alum occasions a copious crimson precipitate, especially if alkali is added at the same time. Sulphat of iron renders the decoction black. The precipitate produced by muriat of tin is rose coloured; that by acetite of lead of a fine deep red *.

The decoction of Brazil wood is fitter for dyeing after it has stood some time, and undergone a kind of fermentation.

* Berthollet, ii. 240.

7. None of the red colouring matters has so strong an affinity for cloth as to produce a permanent red, without the assistance of mordants. The mordants employed are alumina and oxide of tin; oil and tan, in certain processes, are also used; and tartar and muriat of soda are frequently called in as auxiliaries. 438 Red requires a mordant.

8. Coarse woollen stuffs are dyed red with madder or

(H) If we believe Tournefort, this dye-stuff was known to the ancients. They employed it to dye the colour known by the name of *purple* of Amorgos, one of the Cyclades islands. If this account be accurate, the knowledge of it had been lost during the dark ages. It was accidentally discovered by a Florentine merchant about the year 1300, who observed, that urine gave a very fine colour to the lichen roccella. Mr Dufay discovered, that archil possesses the property of tinging indelibly white marble, of forming veins, and giving it the appearance of jasper. See *Mem. Par.* 1732.

(I) The tincture of archil is used for making *spirit of wine thermometers*. It is a singular fact, that this tincture becomes gradually colourless when excluded from the contact of air, and that it again recovers its colour when exposed to the atmosphere. The phenomenon was first observed by the Abbé Nollet, and described by him in an essay, published among the memoirs of the Academy of Sciences for 1742.

Red. or archil; but fine cloth is almost exclusively dyed with cochineal; though the colour which it receives from kermes is much more durable. Brazil wood is scarcely used, except as an auxiliary; because the colour which it imparts to wool is not permanent.

439 Wool how dyed crimson, Wool is dyed *crimson*, by first impregnating it with alumina by means of an alum bath, and then boiling it in a decoction of cochineal till it has acquired the wished-for colour. The crimson will be finer if the tin mordant be substituted for alum: indeed it is usual with dyers to add a little nitro-muriat of tin when they want fine crimsons. The addition of archil and potass to the cochineal, both renders the crimson darker and gives it more bloom; but the bloom very soon vanishes. For paler crimsons, one-half of the cochineal is withdrawn, and madder substituted in its place.

440 And scarlet. Wool may be dyed *scarlet*, the most splendid of all colours, by first boiling it in a solution of murio-sulphat of tin; then dyeing it pale yellow with quercitron bark, and afterwards crimson with cochineal: For scarlet is a compound colour, consisting of *crimson* mixed with a little *yellow*. This method was suggested by Dr Bancroft, who first explained the nature of the common method. The proportions which he gives are eight parts of murio-sulphat of tin for a 100 parts of cloth. After the cloth has been boiled in this solution for a quarter of an hour, it is to be taken out, and about four parts of cochineal, and two and a half parts of quercitron bark, are to be thrown into the bath. After these are well mixed, the cloth is to be returned again to the bath, and boiled in it, till it has acquired the proper colour *.

* Bancroft, i. 291.

The common process for dyeing scarlet is as follows: Twelve parts of tartar are dissolved in warm water; then one part of cochineal is added, and soon after ten parts of nitro-muriat of tin. When the bath boils, 100 parts of cloth are put in, turned briskly through the bath, boiled in it for two hours; then taken out, aired, washed, and dried. Into another bath eleven parts of cochineal are put; and after its colouring matter is sufficiently extracted, 28 parts of nitro-muriat of tin are added. In this bath the cloth is boiled for an hour, and then washed and dried.

Every preceding writer on dyeing took it for granted, that the yellow tinge necessary for scarlet was produced by the nitro-muriat of tin, or rather by the nitric acid of that compound, and that the tartar was only useful in enlivening the colour. But Dr Bancroft ascertained, by actual experiment, that nitro-muriat of tin has no such effect; that cloth, impregnated with this or any other tin mordant, and afterwards dyed with cochineal, acquires only a crimson colour, unless tartar be added; that the tartar has the property of converting part of the cochineal to yellow; and therefore is the real agent in producing the scarlet colour. Good scarlet, indeed, cannot be made without tin; because every other mordant sullies the colour, and renders it dull †.

† Ibid. 288.

441 Red dyes employed for silk, 9. Silk is usually dyed red with cochineal or carthamus, and sometimes with Brazil wood. Kermes does not answer for silk; madder is scarcely ever used for that purpose, because it does not yield a bright enough colour. Archil is employed to give silk a bloom; but it is scarcely used by itself, unless when the colour wanted is lilac.

Silk may be dyed crimson by steeping it in a solution of alum, and then dyeing it in the usual way in a cochineal bath. But the common process is to plunge the silk, after it has been alumed, into a bath formed of the following ingredients: Two parts of white galls, three parts of cochineal, three-sixteenths of tartar, and three sixteenths of nitro-muriat of tin, for every sixteen parts of silk. The ingredients are to be put into boiling water in the order they have been enumerated; the bath is then to be filled up with cold water; the silk put into it, and boiled for two hours. After the bath has cooled, the silk is usually allowed to remain in it for three hours longer. Red. 442 In dyeing crimson,

The colours known by the names of poppy, cherry, rose, and flesh colour, are given to silk by means of carthamus. The process consists merely in keeping the silk, as long as it extracts any colour, in an alkaline solution of carthamus, into which as much lemon juice as gives it a fine cherry colour has been poured. To produce a deep poppy red, the silk must be put successively into a number of similar baths, and allowed to drain them. When the silk is dyed, the colour is brightened by plunging it into hot water acidulated with lemon juice. The silk ought to be previously dyed yellow with anotta. 443 Poppy,

Cherry red is produced the same way, only the anotta ground is omitted, and less colouring matter is necessary. When a flesh colour is required, a little soap should be put into the bath, which softens the colour, and prevents it from taking too quickly. 444 Cherry, 445 Flesh red,

To lessen the expence, some archil is often mixed with carthamus for dark shades.

The same shades may be dyed by means of Brazil wood, but they do not stand.

Silk cannot be dyed a full scarlet; but a colour approaching to scarlet may be given it, by first impregnating the stuff with murio-sulphat of tin, and afterwards dyeing it in a bath composed of four parts of cochineal and four parts of quercitron bark. To give the colour more body, both the mordant and the dye may be repeated *. A colour approaching scarlet may be also given to silk, by first dyeing it crimson, then dyeing it with *carthamus*, and lastly yellow without heat †. 446 Scarlet.

* Bancroft, i. 312.

† Berthollet, ii. 203.

10. Cotton and linen are dyed red with madder. The process was borrowed from the East; hence the colour is often called *Adrianople* or *Turkey red*. The cloth is first impregnated with oil, then with galls, and lastly with alum, in the manner described in the last section. It is then boiled for an hour in a decoction of madder, which is commonly mixed with a quantity of blood. After the cloth is dyed, it is plunged into a soda ley, in order to brighten the colour. The red given by this process is very permanent, and when properly conducted it is exceedingly beautiful. The whole difficulty consists in the application of the mordant, which is by far the most complicated employed in the whole art of dyeing. 447 How to dye cotton and linen red.

Cotton may be dyed scarlet by means of murio-sulphat of tin, cochineal, and quercitron bark, used as for silk; but the colour is too fading to be of any value *.

* Bancroft, i. 316.

SECT. IV. *Of Black.*

448 Black dyes. 1. THE substances employed to give a black colour to cloth are red oxide of iron and tan. These two substances

Black. ftances have a ftrong affinity for each other; and when combined, affume a deep black colour, not liable to be deftroyed by the action of air and light. The affinity which each of them has for the different kinds of cloth has been already mentioned.

2. Logwood is ufually employed as an auxiliary, becaufe it communicates luftre, and adds confiderably to the fulnefs of the black. It is the wood of the tree called by Linnæus *hæmatoxylum campechianum*, which is a native of feveral of the Weft India iflands, and of that part of Mexico which furrounds the bay of Honduras. It yields its colouring matter to water. The decoction is at firft a fine red bordering on violet, but if left to itfelf it gradually affumes a black colour. Acids give it a deep red colour; alkalies a deep violet, inclining to brown. Sulphat of iron renders it as black as ink, and occafions a precipitate of the fame colour. The precipitate produced by alum is dark red; the fupernatent liquid becomes yellowifh red *.

* *Berthollet*, ii. 255.

3. Cloth, before it receive a black colour, is ufually dyed blue. This renders the colour much fuller and finer than it otherwife would be. If the cloth be coarfe, the blue dye may be too expenfive; in that cafe a brown colour is given by means of walnut peels.

449 How to induce a black on wool, 4. Wool is dyed black by the following procefs. It is boiled for two hours in a decoction of nut galls, and afterwards kept for two hours more in a bath compofed of logwood and fulphat of iron, kept during the whole time at a fcalding heat, but not boiled. During the operation it muft be frequently expofed to the air; becaufe the green oxide of iron, of which the fulphat is compofed, muft be converted into red oxide by abforbing oxygen, before the cloth can acquire a proper colour. The common proportions are five parts of galls, five of fulphat of iron, and 30 of logwood for every 100 of cloth. A little acetite of copper is commonly added to the fulphat of iron, becaufe it is thought to improve the colour.

450 Silk, 5. Silk is dyed nearly in the fame manner. It is capable of combining with a very great deal of tan; the quantity given is varied at the pleafure of the artift, by allowing the filk to remain a longer or fhorter time in the decoction. After the galling, the filk is put into a folution of fulphat of iron, which is ufually mixed with a certain quantity of iron filings and of gum. It is occafionally wrung out of the bath, expofed for fome time to the air, and again immerfed. When it has acquired a fufficiently full colour, it is wafhed in cold water, and afterwards fteeped in a decoction of foap to take off the harfhnefs, which filk always has after being dyed black.

451 Linen, and cotton. 6. It is by no means fo eafy to give a full black to linen and cotton. The cloth, previoufly dyed blue, is fteeped for 24 hours in a decoction of nut galls. A bath is prepared, containing acetite of iron, formed by faturating acetous acid with brown oxide of iron. Into this bath the cloth is put in fmall quantities at a time, wrought with the hand for a quarter of an hour, then wrung out and aired, again wrought in a frefh quautity of the bath, and aftewards aired. Thefe alternate proceffes are repeated till the colour wanted is given. A decoction of alder bark is ufually mixed with the liquor containing the nut galls.

It would probably contribute to the goodnefs and permanence of the colour, if the cloth, before being galled, were impregnated with oil, by being fteeped in a mixture of alkaline ley and oil combined, as is practifed for dyeing cotton red.

SECT. V. *Of Brown*.

Brown. THAT particular *brown* colour, with a caft of *yellow*, which the French call *fauve*, and to which the Englifh writers on *dyeing* have appropriated the word *fawn*, though in fact a compound, is commonly ranked among fimple colours; becaufe it is applied to cloth by a fingle procefs. The fubftances employed to produce this colour are numerous; but we fhall fatisfy ourfelves with enumerating the following:

Walnut peels are the green covering of the walnut, When firft feparated, they are white internally; but foon affume a brown, or even a black colour, on expofure to the air. They readily yield their colouring matter to water. They are ufually kept in large cafks, covered with water, for above a year, before they are ufed. To dye wool brown with them, nothing more is neceffary than to fteep the cloth in a decoction of them till it has acquired the wifhed-for colour. The depth of the fhade is proportional to the ftrength of the decoction. The root, as well as the peel of the walnut tree, contains the fame colouring matter, but in fmaller quantity. The bark of the birch, alfo, and many other trees, may be ufed for the fame purpofe. 452 Brown dyes.

It is very probable, that the brown colouring matter is in thefe vegetable fubftances combined with tan. This is certainly the cafe in fumach, which is often employed to produce a brown. This combination explains the reafon why no mordant is neceffary; the tan has a ftrong affinity for the cloth, and the colouring matter for the tan. The dye ftuff and the mordant are already, in fact, combined together.

CHAP. V. Of Compound Colours.

COMPOUND colours are produced by mixing together two fimple ones; or, which is the fame thing, by dyeing cloth firft one fimple colour, and then another. The refult is a compound colour, varying in fhade according to the proportions of each of the fimple colours employed.

Compound colours are exceedingly numerous, varying almoft to infinity, according to the proportions of the ingredients employed. They may be all arranged under the four following claffes: 453 Division of compound colours.

Mixtures of 1. blue and yellow,
2. blue and red,
3. yellow and red,
4. black and other colours.

To defcribe all the different fhades which belong to each of thefe claffes, would be impoffible; and even if it were poffible, it would be unneceffary; becaufe all the proceffes depend upon the principles laid down in the preceding chapters, and may eafily be conceived and varied by thofe who underftand thefe principles. In the following fections, therefore, it will be fufficient to mention the principal compound colours produced by the mixture of fimple colours, and to exhibit a fpecimen or two of the mode of producing them.

SECT. I. *Of Mixtures of Blue and Yellow*.

THE colour produced by mixtures of blue and yellow is

Mixtures of Blue and Yellow. is *green;* which is diſtinguiſhed by dyers by a great variety of names, according to the depth of the ſhade, or the prevalence of either of the component parts. Thus we have *ſea green*, *meadow* or *graſs green*, *pea green*, &c. &c.

454 How to induce green 455 On wool, Wool is uſually dyed green by giving it firſt a blue colour, and afterwards dyeing it yellow; becauſe, when the yellow is firſt given, ſeveral inconveniences follow: the yellow partly ſeparates again in the blue vat, and communicates a green colour to it; and thus renders it uſeleſs for every other purpoſe, except dyeing green. Any of the proceſſes for dyeing blue, deſcribed in the laſt chapter, may be followed; care being taken always to proportion the depth of the blue to the ſhade of green which is required. The cloth thus dyed blue may receive a yellow colour, by following the proceſſes deſcribed in the laſt chapter for that purpoſe. When the ſulphat of indigo is employed, it is uſual to mix all the ingredients together, and to dye the cloth at once: the colour produced is known by the name of *Saxon*, or *Engliſh green*. One of the moſt convenient methods of conducting this proceſs is the following:

Six or eight parts of quercitron bark, tied up in a bag, are to be put into the dyeing veſſel, which ſhould contain only a ſmall quantity of warm water. When the water boils, ſix parts of murio ſulphat of tin, and four parts of alum, are to be added. In a few minutes, the dyeing veſſel ſhould be filled up with cold water, till the temperature is reduced to about 130°. After this, as much ſulphat of indigo is to be poured in as is ſufficient to produce the intended ſhade of green. When the whole has been ſufficiently ſtirred, a hundred parts of cloth are to be put in, and turned briſkly for about fifteen minutes, till it has acquired the wiſhed-for ſhade *. By this method, a much more beautiful colour is obtained than is given by the uſual proceſs, in which fuſtic is employed to give the yellow ſhade.

* Bancroft, ii. 336.

456 Silk, Silk, intended to receive a green colour, is uſually dyed yellow firſt, by means of weld, according to the proceſs deſcribed in the laſt chapter; afterwards, it is dipped into the blue vat, and dyed in the uſual manner. To deepen the ſhade, or to vary the tint, decoctions of logwood, anotta, fuſtic, &c. are added to the yellow bath. Or ſilk may be dyed at once green, by adding ſuitable proportions of ſulphat of indigo to the common quercitron bark bath, compoſed of four parts of bark, three parts of alum, and two parts of murio-ſulphat of tin †.

† Ibid. 346.

457 Cotton and linen, Cotton and linen muſt be firſt dyed blue, and then yellow, according to the methods deſcribed in the laſt chapter. It is needleſs to add, that the depth of each of theſe colours muſt be proportioned to the ſhade of green colour which it is the intention of the dyer to give.

SECT. II. *Of Mixtures of BLUE and RED.*

458 Violet, purple, lilac, THE mixture of blue and red produces *violet*, *purple*, and *lilac*, of various ſhades, and known by various names, according to the proportion of the ingredients employed. When the colour is deep, and inclines moſt to blue, it is called *violet;* but when the red is prevalent, it gets the name of *purple*. When the ſhade is light, the colour is uſually called *lilac*. For violet, therefore, the cloth muſt receive a deeper blue; for purple, a deeper red; and for lilac, both of theſe colours muſt be light.

Wool is uſually dyed firſt *blue;* the ſhade, even for violet, ought not to be deeper than that called *ſky blue;* afterwards it is dyed ſcarlet, in the uſual manner. The violets and purples are dyed firſt; and when the vat is ſomewhat exhauſted, the cloth is dipped in which is to receive the lilac, and the other lighter ſhades. By means of ſulphat of indigo, the whole proceſs may be performed at once. The cloth is firſt alumed, and then dyed in a veſſel, containing cochineal, tartar, and ſulphat of indigo, in proportions ſuited to the depth of the colour required *. A violet colour may alſo be given to wool, by impregnating it with a mordant compoſed of tin diſſolved in a mixture of ſulphuric and muriatic acids, formed by diſſolving muriat of ſoda in ſulphuric acid: to which ſolution a quantity of tartar and ſulphat of copper is added. The wool is then boiled in a decoction of logwood till it has acquired the wiſhed-for colour †.

Mixtures of Blue and Red. 459 How induced on wool,

* Poerner.

† Decroyzille, Berthollet, ii. 331.

Silk is firſt dyed crimſon, by means of cochineal, in the uſual way, excepting only that no tartar, nor ſolution of tin, is employed: It is then dipped into the indigo vat till it has acquired the wiſhed-for ſhade. The cloth is often afterwards paſſed through an archil bath, which greatly improves the beauty of the colour. Archil is often employed as a ſubſtitute for cochineal: The ſilk firſt receives a red colour, in the uſual way, by being dyed in an archil bath; afterwards it receives the proper ſhade of blue. The violet, or purple, given by this proceſs is very beautiful, but not very laſting ‡. 460 Silk,

‡ Berthollet, ii. 327.

Silk may be dyed violet or purple at once, by firſt treating it with a mordant, compoſed of equal parts of nitro-muriat of tin and alum, and then dipping it into a cochineal bath, into which a proper quantity of ſulphat of indigo has been poured. But this dye is fading; the blue colour ſoon decays, and the ſilk becomes red *.

* Guehliche, Berthollet, ii. 329.

Cotton and linen are firſt dyed blue, then galled, then ſoaked in a decoction of logwood; ſome alum and acetite of copper are added to the decoction, and the cloth is ſoaked again. This proceſs is repeated till the proper colour is obtained †. The colour produced by this method is not nearly equal in permanency to that deſcribed in this *Supplement* under the word IRON; to which we beg leave to refer the reader. The proceſs there deſcribed has been long known; but Mr Chaptal has ſimplified it ſomewhat. 461 Cotton, and linen,

† Berthollet, ii. 337.

SECT. III. *Of Mixtures of YELLOW and RED.*

THE colour produced by the mixture of *red* and *yellow* is *orange;* but almoſt an infinity of ſhades reſults from the different proportions of the ingredients, and from the peculiar nature of the yellow employed. Sometimes *blue* is combined with red and yellow on cloth: the reſulting colour is called *olive*. 462 Orange and olive,

Wool may be dyed orange by preciſely the ſame proceſs which is uſed for ſcarlet, only the proportion of red muſt be diminiſhed, and that of yellow increaſed. When wool is firſt dyed red with madder, and then yellow with weld, the reſulting colour is called *cinnamon colour*. The mordant, in this caſe, is a mixture of alum and tartar. The ſhade may be varied exceedingly, by uſing other yellow dye ſtuffs inſtead of weld, and by varying the proportions, according to circumſtances. Thus a reddiſh yellow may be given to cloth, by firſt dyeing it yellow, and then paſſing it through a madder bath. 463 How induced on wool,

Silk is dyed orange by means of carthamus: the 464 Silk, method

Mixtures of Black with other Colours.

method has been defcribed in the laft chapter. Cinnamon colour is given to it by dyeing it, previoufly alumed, in a bath compofed of the decoctions of logwood, Brazil wood, and fuftic, mixed together.

465 Cotton and linen. Cotton and linen receive a cinnamon colour by means of weld and madder. The procefs is complicated. The cloth is firft dyed with weld and acetite of copper, then dipped in a folution of fulphat of iron, then galled, then alumed, and then dyed in the ufual way with madder *.

For *olive*, the cloth is firft dyed blue, then yellow, and laftly paffed through a madder bath. The fhade depends upon the proportion of each of thefe colours. For very deep fhades the cloth is alfo dipped into a folution of fulphat of iron. Cotton and linen may be dyed *olive* by dipping them into a bath, compofed of the decoction of four parts of weld and one of potafs, mixed with the decoction of Brazil wood and a little acetite of copper †.

* *Bertholl*et, ii. 344.

† *D'Apligny, ibid.* 345.

SECT. IV. *Of Mixtures of* BLACK *with other Colours.*

466 Greys, drabs, and browns. STRICKLY fpeaking, the mixtures belonging to this fection are not mixtures of *black colours* with other colours, but combinations of the *black dye* with other colours; the ingredients of which, galls and brown oxide of iron, being both mordants, varioufly modify other colouring matters by combining with them. Thus if cloth be previoufly combined with brown oxide of iron, and afterwards dyed yellow with quercitron bark, the refult will be a *drab* of different fhades, according to the proportion of mordant employed. When the proportion is fmall, the colour inclines to olive or yellow; on the contrary, the drab may be deepened or faddened, as the dyers fpeak, by mixing a little fumach with the bark *. The precautions formerly mentioned in applying the oxide muft be obferved.

It is very common to dip cloth already dyed fome particular colour into a folution of fulphat of iron, and galls or fome other fubftance containing tan, called the *black bath*, in order to alter the fhade, and to give the colour greater permanency. We fhall give a few inftances: greater minutenefs would be inconfiftent with the nature of this article.

Cloth dyed blue, by being dipped into the *black* bath, becomes *bluifh grey*. Cloth dyed *yellow*, by the fame procefs, becomes *blackifh grey*, *drab*, or *yellowifh brown*. Cloth previoufly alumed, and dyed in a decoction of cochineal and acetite of iron, acquires a permanent *violet colour* inclining to *brown*, or a *lilac*, if the dyeing veffel be fomewhat exhaufted *. Cloth fteeped in a mordant, compofed of alum and acetite of iron diffolved in water, and afterwards dyed in a bath compofed of the decoction of galls and madder mixed together, acquires a fine deep *brown*. The method of varying the fhades of linen and cotton will be readily conceived, after we have given an account of calico printing, which forms the fubject of the next chapter.

* *Bancroft*, i. 343.

* *Gubliche, Bertholl*et, ii. 349.

CHAP. VI. OF CALICO PRINTING.

CALICO printing is the art of communicating different colours to particular fpots or figures on the furface of cotton or linen cloth, while the reft of the ftuff retains its original whitenefs.

Calico Printing.

467 Origin of calico printing. This ingenious art feems to have originated in India, where we know it has been practifed for more than 2000 years. Pliny indeed informs us, that the Egyptians were acquainted with calico printing; but a variety of circumftances combine to render it more than probable that they borrowed it from India. The art has but lately been cultivated in Europe; but the enlightened induftry of our manufacturers has already improved prodigioufly upon the tedious proceffes of their Indian mafters. No art has rifen to perfection with greater celerity: a hundred years ago it was fcarcely known in Europe; at prefent, the elegance of the patterns, the beauty and permanency of the colours, and the expedition with which the different operations are carried on, are really admirable.

A minute detail of the proceffes of calico printing would not only be foreign to the plan of this article, but of very little utility. To the artift the proceffes are already known; an account of them therefore could give him no new information; while it would fatigue and difappoint thofe readers who wifh to underftand the principles of the art. We fhall content ourfelves, therefore, with a fhort view of thefe principles.

468 It confifts in applying mordants partially to cotton, Calico printing confifts in impregnating thofe parts of the cloth which are to receive a colour with a mordant, and then dyeing it as ufual with fome dye ftuff or other. The dye ftuff attaches itfelf firmly only to that part of the cloth which has received the mordant. The whole furface of the cotton is indeed more or lefs tinged; but by wafhing it, and bleaching it for fome days on the grafs with the wrong fide uppermoft, all the unmordanted parts refume their original colour, while thofe which have received the mordant retain it. Let us fuppofe that a piece of white cotton cloth is to receive red ftripes; all the parts where the ftripes are to appear are penciled over with a folution of acetite of alumina. After this, the cloth is dyed in the ufual manner with madder. When taken out of the dyeing veffel, it is all of a red colour; but by wafhing and bleaching, the madder leaves every part of the cloth white except the ftripes impregnated with the acetite of alumina, which remain red. In the fame manner, may yellow ftripes, or any other wifhed-for figure, be given to cloth, by fubftituting quercitron bark, weld, &c. for madder.

469 Which is afterward dyed and bleached.

When different colours are to be given to different parts of the cloth at the fame time, it is done by impregnating it with various mordants. Thus if ftripes be drawn upon a cotton cloth with acetite of alumina, and other ftripes with acetite of iron, and the cloth be afterwards dyed in the ufual way with madder, and then wafhed and bleached, it will be ftriped *red* and *brown*. The fame mordants with quercitron bark give *yellow*, and *olive* or *drab*.

470 Mordant employed. The mordants employed in calico printing are acetite of alumina and acetite of iron, prepared in the manner defcribed in the third chapter of this part. Thefe mordants are applied to the cloth, either with a pencil or by means of blocks, on which the pattern, according to which the cotton is to be printed, is cut. As they are applied only to particular parts of the cloth, care muft be taken that none of them fpread to the part of the cloth which is to be left white, and that they do not interfere with one another when more than one are applied.

Calico Printing.

applied. If theſe precautions be not attended to, all the elegance and beauty of the print muſt be deſtroyed. It is neceſſary, therefore, that the mordants ſhould be of ſuch a degree of conſiſtence that they will not ſpread beyond thoſe parts of the cloth on which they are applied. This is done by thickening them with flour or ſtarch when they are to be applied by the block, and with gum arabic when they are to be put on with a pencil. The thickening ſhould never be greater than is ſufficient to prevent the ſpreading of the mordants; when carried too far, the cotton is apt not to be ſufficiently ſaturated with the mordant; of courſe the dye takes but imperfectly.

471 How applied.

In order that the parts of the cloth impregnated with mordants may be diſtinguiſhed by their colour, it is uſual to tinge the mordants with ſome colouring matter or other. The printers commonly uſe the decoction of Brazil wood for this purpoſe; but Bancroft has objected to this method, becauſe he thinks that the Brazil wood colouring matter impedes the ſubſequent proceſs of dyeing. It is certain, that the colouring matter of the Brazil wood is diſplaced during that operation by the ſuperior affinity of the dye ſtuff for the mordant. Were it not for this ſuperior affinity, the colour would not take at all. Dr Bancroft * adviſes to colour the mordant with ſome of the dye ſtuff afterwards to be applied; and he cautions the uſing of more for that purpoſe than is ſufficient to make the mordant diſtinguiſhable when applied to the cloth. The reaſon of this precaution is obvious. If too much dye be mixed with the mordant, a great proportion of the mordant will be combined with colouring matter; which muſt weaken its affinity for the cloth, and of courſe prevent it from combining with it in ſufficient quantity to enſure a permanent dye.

* *Bancroft*, 373.

Sometimes theſe two mordants are mixed together in different proportions; and ſometimes one or both is mixed with an infuſion of ſumach or of nut galls. By theſe contrivances, a great variety of colours are produced by the ſame dye ſtuff.

472 Subſequent treatment of the cloth.

After the mordants have been applied, the cloth muſt be completely dried. It is proper for this purpoſe to employ artificial heat, which will contribute ſomething towards the ſeparation of the acetous acid from its baſe, and towards its evaporation; by which the mordant will combine in a greater proportion, and more intimately with the cloth.

When the cloth is ſufficiently dried, it is to be waſhed with warm water and cow dung, till all the flour or gum employed to thicken the mordants, and all thoſe parts of the mordants which are uncombined with the cloth, are removed. The cow dung ſerves to entangle theſe looſe particles of mordants, and to prevent them from combining with thoſe parts of the cloth which are to remain white. After this the cloth is thoroughly rinſed in clean water.

473 Dye ſtuffs uſed.

Almoſt the only dye ſtuffs employed by calico printers are, indigo, madder, and quercitron bark or weld. This laſt ſubſtance, however, is now but little uſed by the printers of this country, except for delicate greeniſh yellows. The quercitron bark has almoſt ſuperſeded it; becauſe it gives colours equally good, and is much cheaper, and more convenient, not requiring ſo great a heat to fix it. Indigo, not requiring any mordant, is commonly applied at once either with the block or a pencil. It is prepared by boiling together indigo, potaſs made cauſtic by quicklime, and orpiment: the ſolution is afterwards thickened with gum (K). It muſt be carefully ſecluded from the air, otherwiſe the indigo would ſoon be regenerated, which would render the ſolution uſeleſs. Dr Bancroft has propoſed to ſubſtitute coarſe brown ſugar for orpiment. It is equally efficacious in decompoſing the indigo and rendering it ſoluble; while it likewiſe ſerves all the purpoſes of gum *.

* *Bancroft*, i. 120.

When the cloth, after being impregnated with the mordant, is ſufficiently cleanſed, it is dyed in the uſual manner. The whole of it is more or leſs tinged with the dye ſtuff. It is well waſhed, and then ſpread out for ſome days on the graſs, and bleached with the wrong ſide uppermoſt. This carries the colour off completely from all the parts of the cotton which has not imbibed the mordant, and leaves them of their original whiteneſs, while the mordanted ſpots retain the dye as ſtrongly as ever.

Let us now give an example or two of the manner in which the printers give particular colours to calicoes. Some calicoes are only printed of one colour, others have two, others three, or more, even to the number of eight, ten, or twelve. The ſmaller the number of colours, the fewer in general are the proceſſes.

474 Method of printing drabs.

1. One of the moſt common colours on cotton prints is a kind of nankeen yellow, of various ſhades, down to a deep yellowiſh brown or drab. It is uſually in ſtripes or ſpots. To produce it, the printers beſmear a block, cut out into the figure of the print, with acetite of iron thickened with gum or flour; apply it to the cotton; which, after being dried and cleaned in the uſual manner, is plunged

(K) Different proportions are uſed by different perſons. Mr Hauſſman mixes 25 gallons of water with 16 pounds of indigo well ground (or a greater or ſmaller quantity, according to the quality of the indigo and the depth of colour wanted); to which he adds 30 pounds of good carbonat of potaſs, placing the whole over a fire; and as ſoon as the mixture begins to boil, he adds, by a little at a time, 12 pounds of quicklime, to render the alkali cauſtic, by abſorbing its carbonic acid. This being done, 12 pounds of red orpiment are alſo added to the mixture; which is then ſtirred, and left to boil for ſome little time, that the indigo may be perfectly diſſolved; which may be known by its giving a yellow colour immediately upon being applied to a piece of white tranſparent glaſs. M. Oberkampf, proprietor of the celebrated manufactory at Jouy near Verſailles, uſes a third more of indigo; and others uſe different proportions, not only of indigo, but of lime, potaſs, and orpiment; which all ſeem to anſwer with nearly equal ſucceſs: but with the beſt copper-coloured Guatamala indigo, it is certain that a good blue may be obtained from only half the quantity preſcribed by Mr Hauſſman, by uſing as much ſtone, or oyſter ſhell lime, as of indigo, nearly twice as much potaſs, and a fourth part leſs of orpiment than of indigo. See *Bancroft*, I. 113.

Calico Printing.

plunged into a potafs ley. The quantity of acetite of iron is always proportioned to the depth of the intended fhade.

475 Yellow, 2. For yellow, the block is befmeared with acetite of alumina. The cloth, after receiving this mordant, is dyed with quercitron bark, and then bleached.

476 Red, 3. Red is communicated by the fame procefs, only madder is fubftituted for the bark.

477 Blue, 4. The fine light blues, which appear fo often on printed cottons, are produced, by applying to the cloth a block befmeared with a compofition, confifting partly of wax, which covers all thofe parts of the cloth which are to remain white. The cloth is then dyed in a cold indigo vat; and after it is dry, the wax compofition is removed by means of hot water.

478 Lilac, brown, 5. Lilac, flea brown, and blackifh brown, are given by means of acetite of iron; the quantity of which is always proportioned to the depth of the fhade. For very deep colours, a little fumach is added. The cotton is afterwards dyed in the ufual manner with madder, and then bleached.

479 And dove. 6. Dove colour and drab, by acetite of iron and quercitron bark.

480 Application of different colours to the fame cloth. When different colours are to appear in the fame print, a greater number of operations are neceffary. Two or more blocks are employed, upon each of which that part of the print only is cut which is to be of fome particular colour. Thefe are befmeared with different mordants and applied to the cloth, which is afterwards dyed as ufual. Let us fuppofe, for inftance, that three blocks are applied to cotton; one with acetite of alumina, another with acetite of iron, a third with a mixture of thefe two mordants, and that the cotton is then dyed with quercitron bark, and bleached. The parts impregnated with the mordants would have the following colours.

Acetite of alumina,	- -	Yellow,
iron,	- - -	Olive, drab, dove (L),
The mixture,	- - - -	Olive green, olive.

If part of the yellow be covered over with the indigo liquor, applied with a pencil, it will be converted into *green*: By the fame liquid, blue may be given to fuch parts of the print as require it.

If the cotton be dyed with madder inftead of quercitron bark, the print will exhibit the following colours:

Acetite of alumina,	- - -	Red,
iron,	- - - -	Brown, black,
The mixture,	- - - - -	Purple.

When a greater number of colours are to appear; for inftance, when thofe communicated by bark and thofe by madder are wanted at the fame time, mordants for part of the pattern are to be applied; the cotton is then to be dyed in the madder bath and bleached; then the reft of the mordants, to fill up the pattern, are added, and the cloth is again dyed with quercitron bark and bleached. This fecond dyeing does not much affect the madder colours; becaufe the mordants, which render them permanent, are already faturated. The yellow tinge is eafily removed by the fubfequent bleaching. Sometimes a new mordant is alfo applied to fome of the madder colours; in confequence of which they receive a new permanent colour from the bark. After the laft bleaching, new colours may be added by means of the indigo liquor. The following table will give an idea of the colours which may be given to cotton by thefe complicated proceffes.

I. *Madder dye.*		*Colours.*
Acetite of alumina,	- - -	Red,
iron,	- - - -	Brown, black,
Ditto diluted	- - - -	Lilac,
Both mixed,	- - - - -	Purple.
II. *Bark dye.*		
Acetite of alumina,	- - -	Yellow,
iron,	- - - -	Dove, drab,
Lilac and acetite of alumina,		Olive,
Red and acetite of alumina,		Orange.
III. *Indigo dye.*		
Indigo,	- - -	Blue,
Indigo and yellow,	- -	Green.

Thus no lefs than 12 colours may be made to appear together in the fame print by thefe different proceffes.

Thefe inftances will ferve to give the reader an idea of the nature of calico printing, and at the fame time afford an excellent illuftration of the importance of mordants in dyeing.

If it were poffible to procure colours fufficiently permanent, by applying them at once to the cloth by the block or the pencil, as is the cafe with the mordants, the art of calico printing would be brought to the greateft poffible fimplicity: but at prefent this can only be done in one cafe, that of indigo; every other colour requires dyeing. Compofitions indeed may be made by previoufly combining the dye ftuff and the mordants. Thus *yellow* may be applied at once by employing a mixture of the infufion of quercitron bark and acetite of alumina; *red*, by mixing the fame mordant with the decoction of alumina, and fo on. Unfortunately the colours applied in this way are far inferior in permanency to thofe produced when the mordant is previoufly combined with the cloth, and the dye ftuff afterwards applied feparately. In this way are applied almoft all the fugitive colours of calicoes which wafhing or even expofure to the air deftroys. 481 Colours fo penciling.

As the application of colours in this way cannot always be avoided by calico printers, every method of rendering them more permanent is an object of importance. We fhall therefore conclude this chapter with a defcription of feveral colours of this kind propofed by Dr Bancroft, which have a confiderable degree of permanence.

A *yellow* printing colour may be formed by the following method: Let three pounds of alum, and three ounces of clean chalk, be firft diffolved in a gallon of hot water, and then add two pounds of fugar of lead; ftir this mixture occafionally during the fpace of 24 or 36 hours, then let it remain 12 hours at reft, and afterwards decant and preferve the clear liquor; this being

(L) According to the proportion of acetite of iron employed

Calico Printing.

ing done, pour ſo much more warm water upon the remaining ſediment, as after ſtirring and leaving the mixture to ſettle will afford clear liquor enough to make, when mixed with the former, three quarts of this aluminous mordant or acetite of alumine. Then take not leſs than ſix, nor more than eight, pounds of quercitron bark properly ground; put this into a tinned copper veſſel, with four or five gallons of clean ſoft water, and make it boil for the ſpace of one hour at leaſt, adding a little more water, if at any time the quantity of liquor ſhould not be ſufficient to cover the ſurface of the bark: the liquor having boiled ſufficiently, ſhould be taken from the fire, and left undiſturbed for half an hour, and then the clear decoction ſhould be poured off through a fine ſieve or canvas ſtrainer. This being done, let ſix quarts more of clear water be poured upon the ſame bark, and made to boil ten or fifteen minutes, both having been firſt well ſtirred; and being afterwards left a ſufficient time to ſettle, the clean decoction may then be ſtrained off, and put with the former into a ſhallow wide veſſel to be evaporated by boiling, until what remains, being joined to the three quarts of aluminous mordant before mentioned, and to a ſufficient quantity of gum or paſte for thickening, will barely ſuffice to make three gallons of liquor in the whole. It will be proper, however, not to add the aluminous mordant, until the decoction is ſo far cooled as to be but little more than blood warm; and theſe being thoroughly mixed by ſtirring, may afterwards be thickened by the gum of Senegal or by gum arabic, if the mixture is intended for penciling; or by a paſte made with ſtarch or flour, if it be intended for printing.

By ſubſtituting a pound of murio ſulphat of tin for the aluminous mordant in the above compoſition, a mixture may be formed which affords a very bright and full yellow, of conſiderable durability.

Sulphat of tin, mixed with a decoction of quercitron bark, communicates to cotton a *cinnamon* colour, which is ſufficiently permanent*.

When the decoctions of quercitron bark and logwood are boiled together, and ſuitable proportions of ſulphat of copper and of verdigris are added to them, with a little carbonat of potaſs, a compound is formed which gives a *green* colour to cotton. Bancroft has made trial of this; and though it has not fully anſwered his expectation, his attempts were attended with ſufficient ſucceſs to determine him to perſevere in his experiments†.

If acetite of iron be mixed with a decoction of quercitron bark, and the mixture be properly thickened, the compound will communicate to cotton a *drab* colour of ſome durability. This compound, mixed with the olive colouring liquor above deſcribed, will produce an olive. If a ſolution of iron, by a diluted muriatic acid, or by a diluted nitric acid, be employed for this purpoſe inſtead of iron liquor, it will produce colours a little more laſting; but theſe ſolutions ſhould be employed ſparingly, that they may not hurt the texture of the linen or cotton to which they are intended to be applied.

* *Bancroft*, i. 400.

† *Ibid*, 401.

Subtriple || Sulphuret.

SUBTRIPLE, is when one quantity is the 3d part of another; as 2 is ſubtriple of 6. And *Subtriple Ratio* is the ratio of 1 to 3.

SUBTRIPLICATE RATIO, is the ratio of the cube roots. So the ſubtriplicate ratio of a to b, is the ratio of $\sqrt[3]{a}$ to $\sqrt[3]{b}$, or of $a^{\frac{1}{3}}$ to $b^{\frac{1}{3}}$.

SUCCESSION OF SIGNS, in aſtronomy, is the order in which they are reckoned, or follow one another, and according to which the ſun enters them; called alſo *conſequentia*. As Aries, Taurus, Gemini, Cancer, &c.

SULPHURET OF LIME having lately been recommended by an eminent chemiſt* as a ſubſtitute for *potaſh* in the new method of bleaching, which, if it anſwer, may certainly be afforded at leſs expence, we ſhall here give the method of preparing the ſulphuret.

* *W. Higgins, M. R. I. A.*

Take of ſulphur, or brimſtone in fine powder, four pounds; lime, well ſlaked and ſifted, twenty pounds; water ſixteen gallons:—theſe are all to be well mixed and boiled for about half an hour in an iron veſſel, ſtirring them briſkly from time to time. Soon after the agitation of boiling is over, the ſolution of the ſulphuret of lime clears, and may be drawn off free from the inſoluble matter, which is conſiderable, and which reſts upon the bottom of the boiler (A). The liquor in this ſtate is pretty nearly of the colour of ſmall beer, but not quite ſo tranſparent.

Sulphuret, Sun.

Sixteen gallons of freſh water are afterwards to be poured upon the inſoluble dregs in the boiler, in order to ſeparate the whole of the ſulphuret from them. When this clears (being previouſly well agitated), it is alſo to be drawn off and mixed with the firſt liquor; to theſe again thirty-three gallons more of water may be added, which will reduce the liquor to a proper ſtandard for ſteeping the cloth.

Here we have (an allowance being made for evaporation, and for the quantity retained in the dregs) ſixty gallons of liquor from four pounds of brimſtone.

Although ſulphur by itſelf is not in any ſenſible degree ſoluble in water, and lime but very ſparingly ſo, water diſſolving but about one ſeven-hundredth part of its weight of lime; yet the ſulphuret of lime is highly ſoluble.

When the above proportion of lime and ſulphur is boiled with only twelve gallons of water, the ſulphuret partly cryſtallizes upon cooling; and when once cryſtallized it is not eaſy of ſolution.

SUN (ſee ASTRONOMY-*Index*, Encycl.) is certainly that celeſtial body which, of all others, ſhould moſt attract our attention. It has accordingly employed much of

(A) Although lime is one of the conſtituent principles of the ſulphuret, yet being ſo intimately united to the ſulphur, it has no longer the property of lime; upon the ſame principle that ſulphuric acid in ſulphat of potaſh has not the property of that acid.

of the time and meditation, not only of the aſtronomer but alſo of the ſpeculative philoſopher, in all ages of the world; and many hypotheſes have been formed, and ſome diſcoveries made, reſpecting the nature and the uſes of this vaſt luminary.

Sir Iſaac Newton has ſhewn, that the ſun, by its attractive power, retains the planets of our ſyſtem in their orbits: he has alſo pointed out the method whereby the quantity of matter which it contains may be accurately determined. Dr Bradley has aſſigned the velocity of the ſolar light with a degree of preciſion exceeding our utmoſt expectation. Gallileo, Scheiner, Hevelius, Caſſini, and others, have aſcertained the rotation of the ſun upon its axis, and determined the poſition of its equator. By means of the tranſit of Venus over the diſk of the ſun, our mathematicians have calculated its diſtance from the earth, its real diameter and magnitude, the denſity of the matter of which it is compoſed, and the fall of heavy bodies on its ſurface. We have therefore a very clear notion of the vaſt importance and powerful influence of the ſun on its planetary ſyſtem; but with regard to its internal conſtruction, we are yet extremely ignorant. Many ingenious conjectures have indeed been formed on the ſubject; a few of which we ſhall mention as an introduction to Dr Herſchel's, of which, as it is the lateſt, and perhaps the moſt plauſible, we ſhall give a pretty full account nearly in his own words.

The dark ſpots in the ſun, for inſtance, have been ſuppoſed to be ſolid bodies revolving very near its ſurface. They have been conjectured to be the ſmoke of volcanoes, or the ſcum floating upon an ocean of fluid matter. They have alſo been taken for clouds. They were explained to be opaque maſſes ſwimming on the fluid matter of the ſun, dipping down occaſionally. It has been ſuppoſed that a fiery liquid ſurrounded the ſun, and that by its ebbing and flowing the higheſt parts of it were occaſionally uncovered, and appeared under the ſhape of dark ſpots: and that by the return of the fiery liquid, they were again covered, and in that manner ſucceſſively aſſumed different phaſes. The ſun itſelf has been called a globe of fire, though perhaps metaphorically. The waſte it would undergo by a gradual conſumption, on the ſuppoſition of its being ignited, has been ingeniouſly calculated; and in the ſame point of view its immenſe power of heating the bodies of ſuch comets as draw very near to it has been aſſigned.

In the year 1779 there was a ſpot on the ſun which was large enough to be ſeen with the naked eye. By a view of it with a ſeven feet reflector, charged with a very high power, it appeared to be divided into two parts. The largeſt of the two, on the 19th of April, meaſured 1′ 8″.06 in diameter, which is equal in length to more than 31,000 miles. Both together muſt certainly have extended above 50,000. The idea of its being occaſioned by a volcanic exploſion violently driving away a fiery fluid, ought to be rejected (ſays Dr Herſchel) on many accounts. "To mention only one, the great extent of the ſpot is very unfavourable to ſuch a ſuppoſition. Indeed a much leſs violent and leſs pernicious cauſe may account for all the appearances of the ſpot. When we ſee a dark belt near the equator of the planet Jupiter, we do not recur to earthquakes and volcanoes for its origin. An atmoſphere, with its natural changes, will explain ſuch belts. Our ſpot on the ſun may be accounted for on the ſame principles. The earth is ſurrounded by an atmoſphere compoſed of various elaſtic fluids. The ſun alſo has its atmoſphere; and if ſome of the fluids which enter into its compoſition ſhould be of a ſhining brilliancy, in the manner that will be explained hereafter, while others are merely tranſparent, any temporary cauſe which may remove the lucid fluid will permit us to ſee the body of the ſun through the tranſparent ones. If an obſerver were placed on the moon, he would ſee the ſolid body of the earth only in thoſe places where the tranſparent fluids of our atmoſphere would permit him. In others, the opaque vapours would reflect the light of the ſun without permitting his view to penetrate to the ſurface of our globe. He would probably alſo find, that our planet had occaſionally ſome ſhining fluids in its atmoſphere; as, not unlikely, ſome of our northern lights might not eſcape his notice, if they happened in the unenlightened part of the earth, and were ſeen by him in his long dark night. Nay, we have pretty good reaſon to believe, that probably all the planets emit light in ſome degree; for the illumination which remains on the moon in a total eclipſe cannot be entirely aſcribed to the light which may reach it by the refraction of the earth's atmoſphere. For inſtance, in the eclipſe of the moon October 22. 1790, the rays of the ſun refracted by the atmoſphere of the earth towards the moon, admitting the mean horizontal refraction to be 30′ 50″.8, would meet in a focus 189,000 miles beyond the moon; ſo that conſequently there could be no illumination from rays refracted by our atmoſphere. It is, however, not improbable, that about the polar regions of the earth there may be refraction enough to bring ſome of the ſolar rays to a ſhorter focus. The diſtance of the moon at the time of the eclipſe would require a refraction of 54′ 6″, equal to its horizontal parallax at that time, to bring them to a focus ſo as to throw light on the moon.

The unenlightened part of the planet Venus has alſo been ſeen by different perſons; and not having a ſatellite, thoſe regions that are turned from the ſun cannot poſſibly ſhine by a borrowed light; ſo that this faint illumination muſt denote ſome phoſphoric quality of the atmoſphere of Venus.

In the inſtance of the large ſpot on the ſun already mentioned, Dr Herſchel concludes, from appearances, that he viewed the real body of the ſun itſelf, of which we rarely ſee more than its ſhining atmoſphere. In the year 1783 he obſerved a fine large ſpot, and followed it up to the edge of the ſun's limb. Here he took notice that the ſpot was plainly depreſſed below the ſurface of the ſun, and that it had very broad ſhelving ſides. He alſo ſuſpected ſome part, at leaſt, of the ſhelving ſides to be elevated above the ſurface of the ſun; and obſerved that, contrary to what uſually happens, the margin of that ſide of the ſpot which was fartheſt from the limb was the broadeſt.

The luminous ſhelving ſide of a ſpot may be explained by a gentle and gradual removal of the ſhining fluid, which permits us to ſee the globe of the ſun. As to the uncommon appearance of the broadeſt margin being on that ſide of the ſpot which was fartheſt from the limb when the ſpot came near the edge of it, we may ſurmiſe that the ſun has inequalities on its ſurface, which may

may poſſibly be the cauſe of it. For when mountainous countries are expoſed, if it ſhould chance that the higheſt parts of the landſcape are ſituated ſo as to be near that ſide of the margin or penumbra of the ſpot which is towards the limb, they may partly intercept our view of it when the ſpot is ſeen very obliquely. This would require elevations at leaſt five or ſix hundred miles high; but conſidering the great attraction exerted by the ſun upon bodies at its ſurface, and the ſlow revolution it has upon its axis, we may readily admit inequalities to that amount. From the centrifugal force at the ſun's equator, and the weight of bodies at its ſurface, he computes, that the power of throwing down a mountain by the exertion of the former, balanced by the ſuperior force of keeping it in its place of the latter, is near $6\frac{1}{2}$ times leſs on the ſun than on our equatorial regions; and as an elevation ſimilar to one of three miles on the earth would not be leſs than 334 miles on the ſun, there can be no doubt but that a mountain much higher would ſtand very firmly. The little denſity of the ſolar body ſeems alſo to be in favour of the height of its mountains; for, *cæteris paribus*, denſe bodies will ſooner come to their level than rare ones. The difference in the vaniſhing of the ſhelving ſide, inſtead of explaining it by mountains, may alſo, and perhaps more ſatisfactorily, be accounted for from the real difference of the extent, the arrangement, the height, and the intenſity of the ſhining fluid, added to the occaſional changes that may happen in theſe particulars during the time in which the ſpot approaches to the edge of the diſk. However, by admitting large mountains on the face of the ſun, we ſhall account for the different opinions of two eminent aſtronomers; one of whom believed the ſpots depreſſed below the ſurface of the ſun, while the other believed them elevated above it. For it is not impoſſible that ſome of the ſolar mountains may be high enough occaſionally to project above the ſhining elaſtic fluid, when, by ſome agitation or other cauſe, it is not of the uſual height; and this opinion is much ſtrengthened by the return of ſome remarkable ſpots which ſerved Caſſini to aſcertain the period of the ſun's rotation. A very high country, or chain of mountains, may oftener become viſible, by the removal of the obſtructing fluid, than the lower regions, on account of its not being ſo deeply covered with it.

In 1791 the Doctor examined a large ſpot on the ſun, and found it evidently depreſſed below the level of the ſurface. In 1792 he examined the ſun with ſeveral powers from 90 to 500, when it appeared evidently, that the black ſpots are the opaque ground, or body of the ſun; and that the luminous part is an atmoſphere, which, being interrupted or broken, gives us a tranſient glimpſe of the ſun itſelf. He perceived likewiſe, that the ſhining ſurface of the ſun is unequal, many parts of it being elevated and others depreſſed; and that the elevations, to which Hevelius gave the name of *faculæ*, ſo far from reſembling torches, were rather like the ſhrivelled elevations upon a dried apple, extended in length, and moſt of them joined together, making waves or waving lines. The faculæ being elevations, very ſatisfactorily explains the reaſon why they diſappear towards the middle of the ſun, and reappear on the other margin; for about the place where we loſe them, they begin to be edgewiſe to our view; and if between the faculæ ſhould lie dark ſpots, they will moſt frequently break out in the middle of the ſun, becauſe they are no longer covered by the ſide-views of theſe faculæ.

The Doctor gives a very particular account of all his obſervations, which ſeem to have been accurately made, and we need ſcarcely add with excellent teleſcopes. For that account, however, we muſt refer to the memoir itſelf, and haſten to lay before our readers the reſult of his obſervations. "That the ſun (ſays he) has a very extenſive atmoſphere, cannot be doubted; and that this atmoſphere conſiſts of various elaſtic fluids, that are more or leſs lucid and tranſparent, and of which the lucid one is that which furniſhes us with light, ſeems alſo to be fully eſtabliſhed by all the phenomena of its ſpots, of the faculæ, and of the lucid ſurface itſelf. There is no kind of variety in theſe appearances but what may be accounted for with the greateſt facility, from the continual agitation which, we may eaſily conceive, muſt take place in the regions of ſuch extenſive elaſtic fluids.

"It will be neceſſary, however, to be a little more particular as to the manner in which I ſuppoſe the lucid fluid of the ſun to be generated in its atmoſphere. An analogy that may be drawn from the generation of clouds in our own atmoſphere, ſeems to be a very proper one, and full of inſtruction. Our clouds are probably decompoſitions of ſome of the elaſtic fluids of the atmoſphere itſelf, when ſuch natural cauſes, as in this grand chemical laboratory are generally at work, act upon them: we may therefore admit, that in the very extenſive atmoſphere of the ſun, from cauſes of the ſame nature, ſimilar phenomena will take place; but with this difference, that the continual and very extenſive decompoſitions of the elaſtic fluids of the ſun are of a phoſphoric nature, and attended with lucid appearances, by giving out light.

"If it ſhould be objected, that ſuch violent and unremitting decompoſitions would exhauſt the ſun, we may recur again to our analogy, which will furniſh us with the following reflections. The extent of our own atmoſphere, we ſee, is ſtill preſerved, notwithſtanding the copious decompoſitions of its fluids in clouds and falling rain; in flaſhes of lightning, in meteors, and other luminous phenomena; becauſe there are freſh ſupplies of elaſtic vapours continually aſcending to make good the waſte occaſioned by thoſe decompoſitions. But it may be urged, that the caſe with the decompoſition of the elaſtic fluids in the ſolar atmoſphere would be very different, ſince light is emitted, and does not return to the ſun, as clouds do to the earth when they deſcend in ſhowers of rain. To which I anſwer, that, in the decompoſition of phoſphoric fluids, every other ingredient but light may alſo return to the body of the ſun. And that the emiſſion of light muſt waſte the ſun, is not a difficulty that can be oppoſed to our hypotheſis: for as it is an evident fact that the ſun does emit light, the ſame objection, if it could be one, would equally militate againſt every other aſſignable way to account for the phenomenon.

"There are, moreover, conſiderations that may leſſen the preſſure of this alledged difficulty. We know the exceeding ſubtility of light to be ſuch, that in ages of time its emanation from the ſun cannot very ſenſibly leſſen the ſize of this great body. To this may be added, that very poſſibly there may always be ways of reſtoration to compenſate for what is loſt by the emiſ-

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ſion of light, though the manner in which this can be brought about ſhould not appear to us. Many of the operations of Nature are carried on in her great laboratory which we cannot comprehend, but now and then we ſee ſome of the tools with which ſhe is at work. We need not wonder that their conſtruction ſhould be ſo ſingular as to induce us to confeſs our ignorance of the method of employing them; but we may reſt aſſured that they are not a mere *luſus naturæ*." Here he alludes to the great number of ſmall teleſcopic comets; which he ſuppoſes, as others had done before him, may be employed to reſtore to the ſun what had been loſt by the emiſſion of light. "My hypotheſis, however, (continues he) does not lay me under any obligation to explain how the ſun can ſuſtain the waſte of light, nor to ſhew that it will ſuſtain it for ever; and I ſhould alſo remark that, as in the analogy of generating clouds, I merely allude to their production as owing to a decompoſition of ſome of the elaſtic fluids of our atmoſphere, that analogy, which firmly reſts upon the fact, will not be leſs to my purpoſe, to whatever cauſe theſe clouds may owe their origin. It is the ſame with the lucid clouds, if I may ſo call them, of the ſun. They plainly exiſt, becauſe we ſee them; the manner of their being generated may remain an hypotheſis—and mine, till a better can be propoſed, may ſtand good; but whether it does or not, the conſequences I am going to draw from what has been ſaid will not be affected by it."

Before he proceeds to draw theſe conſequences, he informs us that, according to the above theory, a dark ſpot in the ſun is a place in its atmoſphere, which happens to be free from luminous decompoſitions; that faculæ are, on the contrary, more copious mixtures of ſuch fluids as decompoſe each other; and that the regions, in which the luminous ſolar clouds are formed, adding thereto the elevation of the faculæ, cannot be leſs than 1843, nor much more than 2765 miles in depth. It is true, continues he, that in our atmoſphere the extent of the clouds is limited to a very narrow compaſs; but we ought rather to compare the ſolar ones to the luminous decompoſitions which take place in our *aurora borealis*, or luminous arches, which extend much farther than the cloudy regions. The denſity of the luminous ſolar clouds, though very great, may not be exceedingly more ſo than that of our *aurora borealis*. For if we conſider what would be the brilliancy of a ſpace two or three thouſand miles deep, filled with ſuch corruſcations as we ſee now and then in our atmoſphere, their apparent intenſity, when viewed at the diſtance of the ſun, might not be much inferior to that of the lucid ſolar fluid.

From the luminous atmoſphere of the ſun, he proceeds to its opaque body; which, by calculation from the power it exerts upon the planets, we know to be of great ſolidity; and from the phenomena of the dark ſpots, many of which, probably on account of their high ſituations, have been repeatedly ſeen, and otherwiſe denote inequalities in their level, we ſurmiſe that its ſurface is diverſified with mountains and valleys.

What has been ſaid, enables us to come to ſome very important concluſions, by remarking, that this way of conſidering the ſun and its atmoſphere removes the great diſſimilarity we have hitherto been uſed to find between its condition and that of the reſt of the great bodies of the ſolar ſyſtem.

The ſun, viewed in this light, appears to be nothing elſe than a very eminent, large, and lucid planet, evidently the firſt, or, in ſtrictneſs of ſpeaking, the only primary one of our ſyſtem, all others being truly ſecondary to it. Its ſimilarity to the other globes of the ſolar ſyſtem with regard to its ſolidity, its atmoſphere, and its diverſified ſurface, the rotation upon its axis, and the fall of heavy bodies, leads us on to ſuppoſe that it is moſt probably alſo inhabited, like the reſt of the planets, by beings whoſe organs are adapted to the peculiar circumſtances of that vaſt globe.

It may, however, not be amiſs to remove a certain difficulty, which ariſes from the effect of the ſun's rays upon our globe. The heat which is here, at the diſtance of 95 millions of miles, produced by theſe rays, is ſo conſiderable, that it may be objected, that the ſurface of the globe of the ſun itſelf muſt be ſcorched up beyond all conception.

This may be very ſubſtantially anſwered by many proofs drawn from natural philoſophy, which ſhew that heat is produced by the ſun's rays only when they act upon a calorific medium; they are the cauſe of the production of heat, by uniting with the matter of fire which is contained in the ſubſtances that are heated; as the colliſion of flint and ſteel will inflame a magazine of gunpowder, by putting all the latent fire it contains into action. But an inſtance or two of the manner in which the ſolar rays produce their effect, will bring this home to our moſt common experience.

On the tops of mountains of a ſufficient height, at an altitude where clouds can very ſeldom reach to ſhelter them from the direct rays of the ſun, we always find regions of ice and ſnow. Now if the ſolar rays themſelves conveyed all the heat we find on this globe, it ought to be hotteſt where their courſe is leaſt interrupted. Again, our aëronauts all confirm the coldneſs of the upper regions of the atmoſphere; and ſince, therefore, even on our earth, the heat of any ſituation depends upon the aptneſs of the medium to yield to the impreſſion of the ſolar rays, we have only to admit, that on the ſun itſelf, the elaſtic fluids compoſing its atmoſphere, and the matter on its ſurface, are of ſuch a nature as not to be capable of any exceſſive affection from its own rays: and indeed this ſeems to be proved by the copious emiſſion of them; for if the elaſtic fluids of the atmoſphere, or the matter contained on the ſurface of the ſun, were of ſuch a nature as to admit of an eaſy chemical combination with its rays, their emiſſion would be much impeded.

Our author then proceeds to ſupport his theory by analogical reaſonings; but as theſe will occur to ſuch of our readers as are converſant with the ſpeculations of aſtronomers, we paſs on to his reflections upon the conſequences of this theory. "That the ſtars are ſuns can hardly admit of a doubt. Their immenſe diſtances would perfectly exclude them from our view, if the light they ſend us were not of the ſolar kind. Beſides, the analogy may be traced much farther. The ſun turns on its axis; ſo does the ſtar Algol; ſo do the ſtars called β Lyræ, δ Cephei, η Antinoi, o Ceti, and many more; moſt probably all. From what other cauſe can we ſo probably account for their periodical changes? Again, our

Sun.

our fun has fpots on its furface; fo has the ftar Algol, and fo have the ftars already named, and probably every ftar in the heavens. On our fun thefe fpots are changeable; fo they are on the ftar ο Ceti, as evidently appears from the irregularity of its changeable luftre, which is often broken in upon by accidental changes while the general period continues unaltered. The fame little deviations have been obferved in other periodical ftars, and ought to be afcribed to the fame caufe. But if ftars are funs, and funs are inhabitable, we fee at once what an extenfive field for animation opens itfelf to our view.

"It is true, that analogy may induce us to conclude, that fince ftars appear to be funs, and funs, according to the common opinion, are bodies that ferve to enlighten, warm, and fuftain a fyftem of planets, we may have an idea of numberlefs globes that ferve for the habitation of living creatures. But if thefe funs themfelves are primary planets, we may fee fome thoufands of them with our own eyes, and millions by the help of telefcopes, when at the fame time the fame analogical reafoning ftill remains in full force with regard to the planets which thefe funs may fupport."

The Doctor then obferves, that from other confiderations, the idea of funs or ftars being *merely* the fupporters of fyftems of planets, is not abfolutely to be admitted as a general one. "Among the great number of very compreffed clufters of ftars I have given (fays he) in my catalogues, there are fome which open a different view of the heavens to us. The ftars in them are fo very clofe together, that, notwithftanding the great diftance at which we may fuppofe the clufter itfelf to be, it will hardly be poffible to affign any fufficient mutual diftance to the ftars compofing the clufter, to leave room for crowding in thofe planets, for whofe fupport thefe ftars have been, or might be, fuppofed to exift. It fhould feem, therefore, highly probable, that they exift for themfelves; and are, in fact, only very capital *lucid*, primary planets, connected together in one great fyftem of mutual fupport.

"The fame remark may be made with regard to the number of very clofe double ftars, whofe apparent diameters being alike, and not very fmall, do not indicate any very great mutual diftance: from which, however, muft be deducted all thofe where the different diftances may be compenfated by the real difference in their refpective magnitudes.

"To what has been faid may be added, that, in fome parts of the milky way, where yet the ftars are not very fmall, they are fo crowded, that in the year 1792, Aug. 22. I found by the gauges that, in 41 minutes of time, no lefs than 258,000 of them had paffed through the field of view of my telefcope.

"It feems, therefore, upon the whole, not improbable, that in many cafes ftars are united in fuch clofe fyftems as not to leave much room for the orbits of planets or comets; and that confequently, upon this account alfo, many ftars, unlefs we would make them mere ufelefs brilliant points, may themfelves be lucid planets, perhaps unattended by fatellites."

What a magnificent idea does this theory give of the univerfe, and of the goodnefs, as well as power, of its Author? And how cold muft be that heart, and clouded that underftanding, who, after the contemplation of it, can for one moment liften to the atheiftical doctrines of thofe men who prefume to account for all the phenomena of nature by chemical affinities and mechanical attraction? The man who, even in his heart, can fay, that fuch an immenfe fyftem, differing fo widely in the ftructure of the different parts of it, but everywhere crowded with life, is the effect of unintelligent agency, is indeed, to ufe the emphatic language of an ancient aftronomer—*a fool.*

Sunda || Sutton.

SUNDA, Straits of, are formed by the approach of the fouth-eaft extremity of the ifland of Sumatra to the north-weft extremity of the ifland of Java (See thefe iflands, *Encycl.*). The ftraits are interfperfed with a number of fmall ifles; the whole difplaying a fcenery fcarcely to be exceeded in the foftnefs, richnefs, and gaiety of its appearance. The two great iflands, which are low, and in fome places marfhy near the fhore, rife afterwards, in a gradual flope, towards the interior of the country, admitting in their afcent every variety of fituation, and all the different tints of verdure. Of the fmaller iflands, a few have fteep and naked fides, fuch as one in the middle of the ftrait, which the Englifh navigators have diftinguifhed, on that account, by the name of Thwart-the-way, and two very fmall round ones, called, from their figures, the Cap and Button (fee thefe iflands, *Suppl.*); but moft of the others are entirely level, founded upon beds of coral, and covered with trees. Some of thefe iflands are furrounded with a white fandy beach, vifited frequently by turtle; but moft of them are adorned with thick fhrubbery to the water's edge, the roots being wafhed by the fea, or the branches dipping into it; and on the outfide are fhoals, in which a multitude of little aquatic animals are bufied in framing calcareous habitations for their refidence and protection. Thofe fabrics gradually emerge above the furface of the water, and at length, by the adventitious adhefion of vegetable matter, giving birth to plants and trees, become new iflands, or add to the fize of thofe already produced by the fame means. It is impoffible not to be ftruck with the diverfified operations of Nature for obtaining the fame end, whether employed in originally fixing the granite foundation of the Brazils, or in throwing up, by fome fudden and fubfequent convulfion, the ifland of Amfterdam, or in continuing to this hour, through the means of animated beings, the formation of new lands in the Straits of Sunda.—*Sir George Staunton's Account of the Britifh Embaffy to China.*

SUNNUD, a grant, patent, or charter, in Bengal.

SUPERPARTICULAR Proportion, or Ratio, is that in which the greater term exceeds the lefs by unit or 1. As the ratio of 1 to 2, or 2 to 3, or 3 to 4, &c.

SUPERPARTIENT Proportion, or Ratio, is when the greater term contains the lefs term once, and leaves fome number greater than 1 remaining. As the ratio

of 3 to 5, which is equal to that of 1 to $1\frac{2}{3}$;

of 7 to 10, which is equal to that of 1 to $1\frac{3}{7}$; &c.

SUPPLEMENT, of an Arch or Angle, in geometry or trigonometry, is what it wants of a femicircle, or of 180°; as the *complement* is what it wants of a quadrant, or of 90°. So, the fupplement of 50° is 130°; as the complement of it is 40°.

SUTTON (Thomas, Efq;), founder of the charterhoufe, was born at Knaith in Lincolnfhire, in 1532, of an

Sutton.

an ancient and genteel family. He was educated at Eton ſchool, and probably at Cambridge, and ſtudied the law in Lincoln's Inn; but this profeſſion not ſuiting his diſpoſition, he travelled into foreign countries, and made ſo long a ſtay in Holland, France, Spain, and Italy, as to acquire the languages of thoſe various nations. During his abſence, his father died, and left him a conſiderable fortune. On his return home, being a very accompliſhed gentleman, he became ſecretary to the earl of Warwick and his brother the earl of Leiceſter. By the former of theſe noblemen, in 1569, he was appointed maſter of the ordnance at Berwick; and diſtinguiſhing himſelf greatly in that ſituation, on the rebellion which at that time broke out in the north, he obtained a patent for the office of maſter-general of the ordnance for that diſtrict for life. He is named as one of the chiefs of thoſe 1500 men who marched into Scotland, by the order of Queen Elizabeth, to the aſſiſtance of the regent, the earl of Morton, in 1573; and he commanded one of the five batteries which obliged the ſtrong caſtle of Edinburgh to ſurrender to the Engliſh. He purchaſed of the biſhop of Durham the manors of Gateſhead and Wickham; which, producing coal-mines, became to him a ſource of extraordinary wealth. In 1580, he was reputed to be worth L. 50,000

Soon after this, he married a rich widow, who brought him a conſiderable eſtate; and taking up the buſineſs of a merchant, riches flowed in to him with every tide. He is ſaid to have had no leſs than thirty agents abroad. He was likewiſe one of the chief victuallers of the navy; and ſeems to have been maſter of the barque called Sutton, in the liſt of volunteers attending the Engliſh fleet againſt the Spaniſh armada. It is probable, alſo, that he was a principal inſtrument in the defeat of it, by draining the bank of Genoa of that money with which Philip intended to equip his fleet, and thereby hindering the invaſion for a whole year. He is likewiſe ſaid to have been a commiſſioner for prizes under Lord Charles Howard, High Admiral of England; and going to ſea with letters of marque, he took a Spaniſh ſhip worth L. 20,000. His whole fortune, at his death, appears to have been in land L. 5000 *per annum*; in money, upwards of L. 60,000; the greateſt eſtate in the poſſeſſion of any private gentleman till much later times. He lived with great munificence and hoſpitality; but loſing his lady in 1602, he retired from the world, leſſened his family, and lived in a private frugal manner; and, having no iſſue, reſolved to diſtinguiſh his name by ſome important charity. Accordingly, he purchaſed of the Earl of Suffolk Howward-Houſe, or the late diſſolved charter-houſe, near Smithfield, for the ſum of L. 13,000, where he founded the preſent hoſpital, in 1611, for the relief of poor men and children. Before he had fixed upon this deſign, the court endeavoured to divert him from his purpoſe, and to engage him to make Charles I. then Duke of York, his heir, by conferring on him a peerage; but being free from ambition, and now near his grave, the luſtre of the coronet could not tempt him to change his plan. He died the 11th of December, 1611, at Hackney, aged 79. His body was conveyed, with the moſt ſolemn proceſſion, to Chriſt-church in London, and there depoſited, till 1614, when it was removed to the charter-houſe, and interred in a vault on the north ſide of the chapel, under a magnificent tomb.

Suworow.

SUWOROW (A) RIMNIKSKY (Count Alexander), was a man ſo eminent in his profeſſion, that, if war be an art founded on ſcience, it would be improper not to give ſome account of his life in a Work of this nature. Various accounts of him, indeed, are already in the hands of the public: but they differ ſo much from one another in the pictures which they preſent of the *man*, that it is not eaſy, if it be always poſſible, to diſtinguiſh truth from falſehood. With reſpect to the talents of the *General*, there is not room for the ſame difference of repreſentation; becauſe a train of military ſucceſſes, almoſt unrivalled, has rendered theſe conſpicuous to all Europe. In the ſhort detail that our limits permit us to give of the life of this ſingular man, we ſhall avail ourſelves of all the information, public and private, which we have been able to obtain, and believe to be authentic; and we hope to make our readers acquainted with ſome particulars reſpecting his perſon and domeſtic habits which are not yet generally known.

The family of Suworow is ſaid to have been from Sweden, and of a noble deſcent. The firſt of this name ſettled in Ruſſia about the latter end of the laſt century; and having engaged in the wars againſt the Tartars and the Poles, were rewarded by the Czars of that period with lands and peaſants. Baſil, the father of our hero, is ſaid to have been the godſon of Peter the Great; to have been held in high eſtimation for his political knowledge and extenſive erudition; and to have enjoyed, at his death, the two-fold rank of General and Senator*.

* See *the Hiſtory of the Campaigns of Count Alexander Suworow, by Frederick Antbing.*

As this account is given by a man who profeſſes to have formed an intimate acquaintance with Suworow himſelf, it ought to be correct; and yet we cannot help entertaining ſome doubts of its truth, or at leaſt of its accuracy. It is well known, that extenſive erudition was in no eſteem in Ruſſia at the period when Baſil Suworow is here ſaid to have been ſo learned; and it is likewiſe known, that if, by erudition, be meant a knowledge of ancient literature, it was even deſpiſed, at a much later period, by all who were at once noble, and poſſeſſed of lands and peaſants (See RUSSIA, *Encycl.*). The truth is, as we have learned from unqueſtionable authority, that the family of Suworow was ancient and reſpectable; but being far from affluent, and their little property lying at the very extremity of the empire, we have reaſon to believe, that the ſubject of this memoir was the firſt of the family that ever was at court. Baſil, however, if his anceſtors were from Sweden, may have been free from the Ruſſian prejudices againſt Greek and Latin; and this is the more probable, that he certainly gave a learned education to his ſon.

That ſon, Alexander Baſilowitch Suworow, was, according to the author already quoted, born in the year

1730;

(A) This name is ſpelled ſometimes as we have ſpelled it, ſometimes SUWARROW, and ſometimes SUVOROF. This laſt is according to the pronunciation; but we have adopted the orthography of the General himſelf, in his letter to Charette, the hero of Vendee.

Suworow. 1730: we have some reason to believe that he was not born before 1732. His father had destined him, we are told, for the robe; but his early inclinations impelled him to the profession of a soldier; and in 1742 he was enrolled as a fusilier in the guards of Seimonow. He was afterwards a corporal, then a serjeant, and, in 1754, he quitted the guards with the brevet of Lieutenant in the army. He made his first campaign in the seven years war against the Prussians, in the year 1759, entering upon actual service under Prince Wolgonski. As senior officer on duty, he attended on the commander in chief Count Fermor, who, admiring the consummate resolution which he appeared to possess, favoured him with his particular confidence. In 1761, he was ordered on service in the light troops under General Berg; and with the rank of a field officer (we think that of Lieutenant-colonel) he performed prodigies of valour, and exhibited much of that character which was afterwards so fully developed and displayed. Even then he seems to have formed the resolution of dying on the field of battle rather than suffer himself to be taken prisoner; for when, with a handful of troops, he was once surrounded by a large detachment of Prussians, he determined to cut his way through them, or perish in the attempt. In this daring enterprise he was not only successful, but contrived to carry off with him twenty prisoners, though he was obliged to abandon two field pieces, which he had a little before taken from a smaller detachment.

At the peace of 1762, he received from the Empress a colonel's commission, written with her own hand; and being advanced, in 1768, to the rank of brigadier, he was, in the month of November, ordered to repair, with all possible speed, to the frontiers of Poland. At that unfavourable season he crossed rivers and morasses, whose passage was rendered more difficult by slight frosts; and, in the course of a month, traversed 500 English miles, with the loss of only a few men in the environs of Smolensko.

The object of the Empress, at this time, was to subdue the Polish confederates, and to possess herself of certain provinces of that ill-fated kingdom. How completely she and her two allies, the Emperor of Germany and the King of Prussia, succeeded in their enterprise, has been related elsewhere (see Poland, *Encycl.*). It is sufficient, in this memoir, to observe, that the successes of the Russians were chiefly owing to the military skill and intrepidity of Suworow, who was their only active General, and was indeed, for four years, almost constantly employed in offensive operations against the confederates. Not to mention the numerous actions and skirmishes of an inferior kind, in which his conduct and courage were always displayed, the victory at Staloviz, over a superior force, ably commanded, and the capture of Cracow, were alone sufficient to intitle him to the character which he ever afterwards so well supported. The former of these drew the highest encomiums from the great Frederick of Prussia; and the latter decided the fate of Poland. It is proper to add, that Suworow, on these occasions, did not tarnish his laurels by unnecessary cruelty. When a French officer, who surrendered at Cracow, offered him his sword, according to the custom of war, he refused it, saying, that he would not take the sword of a brave man, whose master was not at war with his sovereign: and, even to the leaders of the confederates, he granted better terms of capitulation than they had the presumption to ask. Suworow.

In the year 1770, he had been promoted to the rank of Major general; and for his exploits in the Polish war, the Empress conferred upon him, at different times, the orders of St Ann, St George, and Alexander Newsky.

After performing some important services on the frontiers of Sweden, Suworow received orders, in the beginning of 1773, to join the army in Moldavia, under the command of Field-marshal Romanzow; and there he began that glorious career, which soon made his name a terror to the Turks. His first exploit was the taking of Turtukey; of which he wrote the following laconic account to the commander in chief:

"Honour and glory to God! Glory to you, Romanzow! We are in possession of Turtukey, and I am in it! "Suworow."

During the remainder of the war, which was of short continuance, Suworow was constantly engaged, and constantly successful. In the beginning of the year 1774, he was promoted to the rank of Lieutenant-general; and on the 11th of June of the same year, he defeated the Turks in a great battle, in which they lost 3000 men killed, some hundreds of prisoners, 40 pieces of artillery, and 80 standards, with their superb camp. Soon after this victory, peace was concluded between the two courts; and Lieutenant-general Suworow was ordered to proceed with all possible haste to Moscow, to assist in appeasing the interior troubles of that part of the empire.

These troubles were occasioned by a Cossac rebel, of the name of *Pugatchew*, or *Pugatcheff*, who, at the head of a party of his discontented countrymen, had long eluded the vigilance of Count Panin, the commander in chief in Muscovy, and frequently cut off detachments of the army which were sent out in quest of him. The chace of Pugatcheff, for such it may be called, was now wholly entrusted to the well-known activity of Suworow; and that General, after pursuing the rebel with inconceivable rapidity, through woods and deserts, came up with him at a place called Urlask, and carried him prisoner to Count Panin, who sent him to Moscow, where he suffered the punishment due to his crimes. This insurgent, it is said, had at one time collected such a force, and was followed with such enthusiasm, that, if his understanding had been equal to his courage, and his moderation had kept pace with his power, he might have possessed himself of Moscow, and made the Imperial Catharine tremble on her throne.

For several years after the taking of Pugatcheff, Suworow was employed in the Crimea, on the Cuban, and against the Nogay Tartars, in a kind of service which, though it was of the utmost importance to the Empress, and required all the address of the Lieutenant-general, furnished no opportunities for that wonderful display of promptitude and resource which had characterised his more active campaigns. One incident, however, must be mentioned, even in this short memoir, because it shews the natural disposition of the man. During the winter that Suworow passed among the Tartars, he was frequently visited by the chiefs of that nation; and at one of these visits, Mechmed Bey, the chief of the Gedissens, often joked with Mussa Bey, another chief, on his inclination to marry. Mussa Bey

Suworow. was fo extremely old, that Suworow thought the converfation ridiculous; and one day afked him, What ground Mechmed could have for fuch idle talk? Muffa replied, that Mechmed Bey was right; that he wifhed to marry; and that he hoped the General would make him a prefent of a beautiful Tartar girl of fixteen! Suworow immediately bought a young Tartar flave of a Coffac for 100 rubles, and fent her to Muffa Bey; who married her, lived with her a very few years, and died at the age of one hundred and eight! regretted, we are told, by the Lieutenant-general, who regarded him with great efteem and attachment.

In the end of the year 1786, Suworow was promoted to the rank of General in Chief; and, at the breaking out of the war with the Turks in 1787, he fhewed how well he was intitled to that rank, by his mafterly defence of Kinburn; a place of no ftrength, but of great importance, as it is fituated at the mouth of the Dneiper, oppofite to Oczakow. For the zeal and abilities which he difplayed on this occafion, the Emprefs decorated him with the order of St Andrew; gave him fix croffes of the order of St George, to be diftributed, according to his judgment, among fuch of his officers as had moft diftinguifhed themfelves; and, in a very flattering letter, regretted the wounds which he had received in defending the place.

At the fiege of Oczakow, Suworow, who commanded the left wing of the army under Prince Potemkin, received a dangerous wound in the nape of the neck, which was followed by fo fmart a fever, that, for fome time, his life was defpaired of; but he perfevered in his long accuftomed practice of preferring regimen to medicine, and his health was gradually re-eftablifhed. In the year 1789, he was appointed to the command of the army which was to co-operate with the Prince of Saxe Cobourg in Walachia; and, by marches of inconceivable rapidity, he twice, in the fpace of two months, preferved the army of that Prince from inevitable deftruction. Putting himfelf at the head of 8000 Ruffians, and literally running to the aid of his ally, he came up with the Turks in time to change the fate of the day at the battle of Forhani, which was fought on the 21ft of July; and again at Rymnik, which, with 7000 men, he had reached with equal celerity, he gained, on the 22d of September, in conjunction with the Prince, one of the greateft victories that have ever been atchieved. According to the leaft exaggerated account, the Turkifh army, commanded by the Grand-Vifier in perfon, amounted to 90.000 or 100,000 men; of which 70,000 were chofen troops; whilft the army of the allies exceeded not 25,000. At the commencement of the attack, Suworow, who had reconnoitered the country, and formed the plan of the battle, called out to his Ruffians, "My friends, look not at the eyes of your enemies, but at their breafts; it is there that you muft thruft your bayonets." No quarter was given to the Turks; and on this account the Ruffian General has been charged with favage ferocity: but the charge, if not groundlefs, muft be fhared equally between him and the Prince of Cobourg. The commanders of the allied army, aware of the immenfe fuperiority of their enemies, had refolved, before the engagement, not to encumber themfelves with prifoners, whom they could not fecure without more than hazarding the fate of the day: And where is the man, who admits the lawfulnefs of war, that will condemn fuch conduct in fuch critical circumftances? Suworow.

The taking of Bender and Belgrade were the immediate confequences of the victory of Rymnic; and fo fenfible was the Emperor Jofeph how much the rapid movements and military fkill of Suworow had contributed to that victory, that he immediately created him a Count of the Roman empire, and accompanied the diploma with a very flattering letter. Similar honours were conferred upon him by his own fovereign, who fent him the diploma of Count of the empire of Ruffia, with the title of Rymnikfki, and the order of St Andrew of the firft clafs.

In the autumn of 1790, Prince Potemkin wrote to Count Suworow, requefting a particular conference. The General, who conjectured the object of it, fent him the following anfwer: "The flotilla of row-boats will get poffeffion of the mouths of the Danube; Tulcia and Ifaccia will fall into our power; our troops, fupported by the veffels, will take Ifmailow and Brahilow, and make Tchiftow tremble." He was perfectly right in his conjecture: it was to concert with him meafures for the taking of Ifmailow that the Prince had requefted the conference. He did not, however, receive orders to undertake that defperate enterprife till the beginning of November, when he rapidly approached towards the fortrefs. His army, by fea and land, confifted of 23,000 men; of whom one-half were Coffacs, and of thefe many were fick. The troops of the garrifon, which were under the orders of feven Sultans, amounted to 43,000 men, of whom nearly one-half were Janiffaries; the fortrefs was by much the ftrongeft of any on the Turkifh frontier: it was under the command of an old warrior, who had twice refufed the dignity of Grand Vifier, and had difplayed againft the Auftrians confiderable abilities, as well as the moft intrepid courage; and the Grand Seignior had publifhed a firman, forbidding the garrifon, on pain of death without trial, to furrender on any terms whatever.

Potemkin, knowing that Suworow had with him no battering cannon, and dreading the confequences of a repulfe, wrote to the General, that if he was not certain of fuccefs, he would do well not to rifk an affault. The laconic reply was; "My plan is fixed. The Ruffian army has already been twice at the gates of Ifmailow; and it would be fhameful to retreat from them the third time without entering the place." To fpare the effufion of blood, however, if poffible, he fent a note to the Serafkier who commanded in Ifmailow, to affure him, upon Count Suworow's word of honour, that if he did not hang out a white flag that very day, the place would be taken by affault, and all the garrifon put to the fword. The Serafkier returned no anfwer to the note; but another commander was pleafed to fay, that "The Danube would ceafe to flow, or the heavens bow down to the earth, before Ifmailow would furrender to the Ruffians!"

Having concerted with the Admiral proper meafures for the affault, Suworow paffed the night with fome officers of his fuite, in impatient vigilance for the appointed hour when the fignals were to be given. Thefe were the firing of a mufket at three, four, and five in the morning, when the army rufhed upon the place; and notwithftanding the defperate oppofition of the Turks, the depth of the moat, and the height of the ramparts, Suworow. ramparts, they were completely masters of Ismailow by four o'clock P. M. In this one dreadful day the Ottomans lost 33,000 men killed or dangerously wounded; 10,000 who were taken prisoners; besides 6000 women and children, and 2000 Christians of Moldavia, who fell in the general massacre. The place was given up to plunder for three days, according to agreement with the army before the assault; but we have authority to say, that no person was murdered in cold blood, who did not prefer his property to his life.

The Russians found in Ismailow 232 pieces of cannon, many large and small magazines of gunpowder, an immense quantity of bombs and balls, 345 standards almost all stained with blood, provisions for the Turkish army for six months, and about 10,000 horses, of which many were extremely beautiful. Suworow, who was inaccessible to any views of private interest, did not appropriate to himself a single article, not so much as a horse; but having, according to his custom, rendered solemn thanks to God for his victory, wrote to Prince Potemkin the following Spartan letter: "The Russian colours wave on the ramparts of Ismailow."

Peace being concluded with the Turks in December 1791, no political events occurred from that period to call forth the military talents of Suworow till 1794. In the beginning of that year mutinies having broken out among the Polish troops in the service of Russia, and the Empress, with her two potent allies, having digested the plan for the partition of Poland, Count Suworow received orders, in the month of May, to proceed, by forced marches, into Red Russia, with a corps of 15,000 men, and to disarm all the Polish troops in that province. This service he performed without the effusion of blood, disarming in less than a fortnight 8000 men, dispersed over a country of 150 miles in circuit. Soon afterwards he was ordered to march into the interior of Poland; the King of Prussia having been obliged to raise the siege of Warsaw, and the Empress perceiving that more vigorous measures than had hitherto been pursued, were necessary to accomplish her designs.

To give a detailed account of his route to Warsaw, would be to write the history of the Polish war, and not the memoirs of Count Suworow. It has been rashly supposed, that he had to contend only with raw troops, commanded by inexperienced leaders, who were not cordially united among themselves; but the fact is otherwise, and Suworow never displayed greater resource in the day of danger, than in the numerous battles and skirmishes in which he was engaged on his march to the capital of Poland. At last, after surmounting every obstacle, he sat down, on the 22d of October, before Praga, a strongly fortified suburb of Warsaw, defended by a formidable artillery, and a garrison of 30,000 men, rendered desperate by their situation. The Russian army exceeded not 22,000; and with that comparatively small force he resolved to storm Praga, as he had stormed Ismail. Having erected some batteries to deceive the garrison into a belief that they were to be regularly besieged, he concerted with the other Generals the mode of assault; and when every thing was ready, he gave his orders in these words: "Storm, and take the batteries, and cut down all who resist; but spare the inhabitants, unarmed persons, and all who shall ask for quarter."

There are but few examples of a military operation so boldly conceived, so skilfully performed, or so important in its consequences, as the taking of Praga. The assault was made at once in seven different places at five in the morning; and at nine the Russians were masters of the place, having penetrated by pure force a triple entrenchment. Of the Poles 13,000 lay dead on the field of battle, one third of whom were the flower of the youth of Warsaw; above 2000 were drowned in the Vistula; and 14,680 were taken prisoners, of whom 8000 were disarmed and immediately set at liberty, and the remainder the next day. We mention these circumstances, because they completely refute the tales of those Jacobin scribblers, who have so strenuously endeavoured to tarnish the laurels of the Russian hero, by representing him as having ordered a general massacre of men, women, and children. The artillery taken from the enemy consisted of 104 pieces of cannon and mortars, chiefly of large calibre. The Russians had 580 men killed, of whom eight were superior and staff officers, and 900 wounded, of whom 23 were officers.

Soon after the storming of Praga, Warsaw capitulated, and Suworow was received into the city by the magistrates in a body, and in their ceremonial habits. When the president presented to him the keys of the city, he pressed them to his lips, and then, holding them up towards heaven, he said, "Almighty God, I render thee thanks, that I have not been compelled to purchase the keys of this place as dear as . . . . ." Turning his face towards Praga, his voice failed him, and his cheeks were instantly bathed with tears. As he rode through the streets, the windows were filled with spectators, who were delighted with the return of order, and the assurance of peace; and the air resounded with the exulting exclamations of "Long live Catharine! Long live Suworow!"

Thus did Count Suworow, in the course of a very few months, overturn the kingdom and republic of Poland. It is not our business, in this article, to decide on the justice of the cause in which he was embarked. Of the Polish revolution, which gave rise to the war that subverted the republic, and swept it from the number of sovereign states, the reader will find some account under the title POLAND in the *Encyclopædia*; but it is here proper to acknowledge, that we do not now think so favourably, as when we wrote that article, of the views and principles of those who framed the constitution, which brought upon them the Russian and Prussian arms. Subsequent events seem to have proved completely, that if Poland had not been conquered by the allied powers, it would soon have been involved, under Kosciusko and his Jacobinical adherents, in all the horrors of revolutionary France; and the unhappy king, instead of being carried captive into Russia, would probably have finished his course on a scaffold. Suworow, who never concerned himself with the intrigues of courts, and expressed on all occasions the most sovereign contempt of those Generals who affected to possess the secrets of statesmen, probably never enquired into the final object of the war, but thought it his duty to execute, in his own sphere, the orders of his Imperial mistress. So sensible was Catharine of the propriety of this conduct, and of the zeal and abilities which he had displayed in the Popish campaign, that immediately on receiving accounts of the storming of Praga

Suworow. Praga and the fubmiffion of Warfaw, fhe announced to him, in a letter written with her own hand, his well-earned advancement to the rank of Field-marfhal General. Nor did her munificence ftop there ; fhe loaded him with jewels, and prefented him with an eftate of 7000 peafants, in the diftrict of Kubin, which had been the fcene of his firft battle in the courfe of the campaign.

From the fubjugation of Poland we hear little more of Field-marfhal Suworow till he entered upon his glorious career in Italy. He is faid, indeed, to have given offence to the prefent Emperor foon after his acceffion to the throne, by affording protection to fome meritorious officers, whom his Majefty had in an arbitrary manner difmiffed from his fervice ; but that offence was overlooked, and Suworow called again into action, when Paul joined the coalition againft France.

Of the exploits of the Field-marfhal in Italy, where, to ufe his own words, he deftroyed armies and overturned ftates, we have given a full account under the title Revolution in this *Supplement*. In his former campaigns, the wifdom of his meafures, the diftribution of his forces, the undaunted character of his operations, and the progreffive continuance of his fucceffes, furnifh proofs of the fuperiority of his talents hardly to be paralleled in the annals of modern war ; but, animated by the noblenefs of his caufe, and confiding, as he faid, in the God of battles, he feems i. his laft campaign to have furpaffed himfelf. It would appear, however, that his own Sovereign thought otherwife ; and if he did, he was certainly as fingular in that opinion as he is faid to have been in many others. Confidering the Field-marfhal as the conqueror of Italy, he had indeed created him a Prince by the ftyle and title of Prince Suworow-*Italifki ;* but how did he receive him, when he returned into the Ruffian dominions at the head of his veteran and victorious bands ?

Though the old warrior thought himfelf almoft betrayed at the end of the campaign by the crooked policy of the court of Vienna, he doubtlefs hoped to be received at the Court of St Peterfburgh, if not with triumphal arches, at leaft with the moft public teftimonies of his Sovereign's approbation. It is faid that he expected to be fent back at the head of a large army, with full powers to act as he fhould judge proper for bringing the war to a happy termination, and reftoring peace and order to Europe ; and he certainly expreffed, in letters to different correfpondents, his earneft wifh to conclude his military career with contributing to the accomplifhment of fo defirable an object. What then muft have been his difappointment, when the Ruffian Emperor would not fee him, and pofitively forbad his appearance at court ? To the meffenger who brought the order, the Field-marfhal gave a purfe of money, turned his carriage another way, and drove to a wooden houfe, at a diftance from the court, and from his former friends, "where burft his mighty heart ;" and the conqueror of the Turks, the Poles, and the French republicans, died, almoft unattended, on the 18th of May 1800. The fovereign, who thus difgraced him at the end of his life, gave him a magnificent funeral !

In his perfon Suworow was tall, confiderably exceeding fix feet, and full chefted. His countenance was Suworow. ftern ; but among his friends his manners were pleafant, and his difpofitions were kind. His temper was naturally violent ; but that violence he conftantly laboured to moderate, though he was never able completely to extinguifh it. According to M. Anthing, an effervefcent fpirit of impatience predominated in his character ; and it perhaps never happened (fays that author) that the execution of his orders equalled the rapidity of his wifhes. Though he difliked all public entertainments, yet when circumftances led him to any of them, he appeared to partake, and endeavoured to promote, the general pleafure. Sometimes he condefcended even to dance and play at cards, though very rarely, and merely that he might not interrupt the etiquette of public manners, to which, when not in the field, he was very attentive. In the field he may be faid to have fpent the whole of his life from the period at which he firft joined the army in the feven years war ; for during the time that he was not engaged in actual warfare, and that time, taken altogether, did not exceed twelve years, he was always placed at the head of armies ftationed on the frontier of fome enemy's country. He was therefore a mere warrior, and as fuch had no fixed habitation. With refpect to his table and lodging, he contented himfelf with whatever he found, requiring nothing but what abfolute neceffity demands, and what might be tranfported with eafe from one place to another. Frequently he caufed the window-fafhes to be taken away, and fometimes the doors : faying, on the former occafion, that he was not cold ; and, on the latter, that he was not afraid. His couch confifted of a heap of frefh hay fufficiently elevated, and fcattered into confiderable breadth, with a white fheet fpread over it, with a cufhion for his pillow, and with a cloak for his coverlid. He has been reprefented as dirty (c) ; but the reprefentation is falfe. M. Anthing afferts, that he was clean in his perfon, and that, when not on actual fervice, he wafhed himfelf frequently during the courfe of the day. It is among the fingular, though unimportant circumftances of his life (fays the fame author), that, for the laft twenty years, he had not made ufe of a looking-glafs, or incumbered his perfon with either watch or money.

He was fincerely religious ; took every opportunity of attending the offices of public devotion ; and has been known, on Sundays and feftivals, to deliver lectures on piety to thofe whom duty called to attend on him. We are told by an anonymous writer, in a mifcellany not very forward to praife fuch men as Suworow, or indeed to praife piety in men of any defcription, that chancing one evening to overhear a captain abridge the prayer which his duty required him to repeat at the guard, the Field-marfhal called out to him, "Thou unconfcionable, abominable, impious man, thou wouldft cheat Heaven ! Thou wouldft, no doubt, cheat likewife the Emprefs and me ! I fhall difmifs thee." His regard for facred things is indeed very apparent in the elegant letter which, on the 1ft of October 1795, he wrote to Charette, the hero of Vendee, whom he congratulates upon taking up arms to reftore the temples of the God of his fathers. Alluding to this trait of his

(c) By the anonymous author of the life of Catharine II.

his character, and to his detestation of Jacobinism under every form, a late writer in a most respectable miscellany has well characterised him as the

"Foe to religion's foe; of Russia's throne
The prop, th' avenger, and the pride in one;
Whose conquering arms, in bold defiance hurl'd,
Crushed the rude monster of the western world."

We have already, when we thought not that we should so soon be called upon to write his life, observed, that he was a scholar, a man of science, and a poet. M. Anthing assures us, that from his earliest years he was enamoured of the sciences, and improved himself in them; but that as the military science was the sole object of his regard, those authors of every nation who investigate, illustrate, or improve it, engrossed his literary leisure. Hence Cornelius Nepos was with him a favourite classic; and he read, with great avidity and attention, the histories of Montecuculi and Turenne. Cæsar, however, and Charles XII. (says the same author) were the heroes whom he most admired, and whose activity and courage became the favourite objects of his imitation.

With respect to his moral character, we have every reason to believe that he was a man of the most incorruptible probity, immoveable in his purposes, and inviolable in his promises; that the cruelties of which he has been accused were the cruelties of Potemkin, and that by those who knew him he was considered as a man of unquestionable humanity. The love of his country, and the ambitiou to contend in arms for its glory, were the predominant passions of his active life; and to them, like the ancient Romans, he sacrificed every inferior sentiment, and consecrated, without reserve, all the powers of his body and mind. His military career was one long and uniform course of success and triumph, produced by his enterprising courage and extraordinary presence of mind; by his personal intrepidity and promptitude of execution; by the rapid and unparalleled movements of his armies; and by their perfect assurance of victory when fighting under his banners. I know not, says a writer *, by no means partial to him or to the cause for which he last fought, whether Suworow was invincible; but it is certain that he died unconquered. No general can boast of having beaten Suworow; and very few, like him, have carried that reputation to the grave, after having, like him, waged war for the space of fourty years, sometimes against the most barbarous people, and sometimes against the most civilized nations. Such was Alexander Besilovitch Count Suworow. In the year 1774 he married a daughter of the General Prince Iwan Prosorowski, by whom he had two children, now living: Natalia, married to General Count Nicolai Zubow; and Arcadius Count Suworow, a youth of great promise, who accompanied his father in his unparalleled march from Italy to Switzerland.

* *Secret Memoirs of the Court of St Petersburgh.*

SWALLOW's-Tail, in fortification, is a single tenaille, which is narrower towards the place than towards the country.

SWAN (See Anas, *Encycl.*). It is now ascertained, beyond the possibility of doubt, that there are *black* swans, of equal size, and the same habitudes, with the common white swan of this island. These fowls have been seen chiefly in New Holland; and Captain Vancouver, when there, saw several of them in very stately attitudes, swimming on the water; and, when flying, discovering the under part of their wings and breasts to be white. Black swans were likewise seen in New Holland by Governor Philips, Captain White, and by a Dutch navigator, so long ago as in 1697. Governor Philips describes the black swan as a very noble bird, larger than the common swan, and equally beautiful in form. Mr White indeed says, that its size is not quite equal to that of the European swan; but both these authors agree with Captain Vancouver in mentioning some white feathers in its wings.

SWINTON (John), a very celebrated English antiquary, was a native of the county of Chester, the son of John Swinton of Bexton in that county, gent. He was born in 1703. The circumstances of his parents were probably not affluent, as he was entered at Oxford in the rank of a servitor at Wadham college. This was in October 1719. It may be presumed that he recommended himself in that society by his talents and behaviour, as on June 30. 1723 he was elected a scholar on a Cheshire foundation in the college. In the December following, he took his first degree in arts. Before he became master of arts (which was on December 1. 1726), he had chosen the church for his profession, and was ordained deacon by the bishop of Oxford, May 30. 1725; and was afterwards admitted to priest's orders on May 28. 1727. He was not long without some preferment, being admitted to the rectory of St Peter le Bailey in Oxford (a living in the gift of the crown), under a sequestration, and instituted to it in February 1728. In June the same year, he was elected a fellow of his college; but, desirous probably to take a wider view of the world, he accepted, not long after, the appointment of chaplain to the English factory at Leghorn, to which he had been chosen. In this situation he did not long enjoy his health; and leaving it on that account, he was at Florence in April 1733, where he attended Mr Coleman, the English envoy, in his last moments. Mr Swinton returned thro' Venice and Vienna; and, in company with some English gentlemen of fortune, visited Presburgh in Hungary, and was present at one of their assemblies.

Biog. Dict.

It is possible that he had not quitted England in the summer of 1730, for he was elected a fellow of the Royal Society in June that year, and admitted about three months later. It was probably while he was abroad that he was admitted into some foreign societies; namely, the academy *degli Apatisti* at Florence, and the *Etruscan Academy* of Cortona. On his return, he seems to have taken up his abode at Oxford, where he resided all the latter part of his life, and was for many years chaplain to the gaol in that city. It many be presumed that he married in 1743; it was then, at least, that he gave up his fellowship. In 1759 he became bachelor of divinity: in 1767, he was elected *Custos Archivorum*, or keeper of the university records: and, on April 4. 1777, he died; leaving no children. His wife survived till 1784, and both were buried, with a very short and plain inscription, in the chapel of Wadham college.

It remains to take notice of the most important monuments of a literary man's life, his publications. These were numerous and learned, but not of great magnitude. He published, 1. "De Linguæ Etruriæ Regalis vernacula Dissertatio," 4to, 19 pages, Oxon, 1738.

2. "A

Swinton. 2. "A critical essay concerning the words Δαιμων and Δαιμονιον, occasioned by two late inquiries into the meaning of the demoniacs in the New Testament," 8vo, London, 1739. 3. "De priscis Romanorum literis dissertatio," 4to, 20 pages, Oxon, 1746. 4. "De Primogenio Etruscorum Alphabeto, dissertatio," Oxon, 1746. 5. "Inscriptiones Citieæ: sive in binas Inscriptiones Phœnicias, inter rudera Citii nuper repertas, conjecturæ. Accedit de nummis quibusdam Samaritanis et Phœniciis, vel insolitam præ se literaturam ferentibus, vel in lucem hactenus non editis, dissertatio," 4to, 87 pages, Oxon, 1750. 6. "Inscriptiones Citieæ: sive in binas alias Inscriptiones Phœnicias, inter rudera Citii nuper repertas, conjecturæ," 4to, 19 pages. 7. "De nummis quibusdam Samaritanis et Phœniciis, vel insolitam præ se literaturam ferentibus, vel in lucem hactenus non editis, dissertatio secunda," 4to, 36 pages. 8. "Metilia: sive de quinario Gentis Metiliæ, è nummis vetustis cæteroquin minimum notæ, dissertatio," 4to, 22 pages, Oxon, 1750. 9. Several dissertations published in the Philosophical Transactions of the Royal Society. As, "A dissertation upon a Parthian Coin; with characters on the reverse resembling those of the Palmyrenes," vol. xlix. p. 593. "Some remarks on a Parthian Coin, with a Greek and Parthian legend, never before published," vol. l. p. 16. "A dissertation upon the Phœnician numeral characters anciently used at Sidon, vol. l. p. 791. "In nummum Parthicum hactenus ineditum conjecturæ," vol. li. p. 683. "A dissertation upon a Samnite Denarius, never before published," vol. lii. p. 28. "An account of a subærated Denarius of the Plætorian family, adorned with an Etruscan inscription on the reverse, never before published or explained," vol. lxii. p. 60. "Observations upon five ancient Persian Coins, struck in Palestine or Phœnicia before the dissolution of the Persian empire," vol. lxii. p. 345. Other papers by him may be found in the general index to the Philosophical Transactions. 10. A part of the Ancient Universal History, contained in the sixth and seventh volumes of that great work. The particulars of this piece of literary history were communicated by Dr Johnson to Mr Nichols, in a paper printed in the Gentleman's Magazine for December 1784, p. 892. The original of that paper, which affords a strong proof of the steady attachment of Johnson to the interests of literature, has been, according to his desire, deposited in the British Museum. The letter is as follows:

"To Mr Nichols.

"The late learned Mr Swinton of Oxford having one day remarked, that one man, meaning, I suppose, no man but himself, could assign all the parts of the Universal History to their proper authors, at the request of Sir Robert Chambers, or of myself, gave the account which I now transmit to you in his own hand, being willing, that of so great a work the history should be known, and that each writer should receive his due proportion of praise from posterity. I recommend to you to preserve this scrap of literary intelligence, in Mr Swinton's own hand, or to deposite it in the Museum, that the veracity of the account may never be doubted.—I am, Sir, your most humble servant,

Dec. 6. 1784. SAM. JOHNSON."

The paper alluded to, besides specifying some parts written by other persons, assigns the following divisions of the history to Mr Swinton himself. "The history of the Carthagians, Numidians, Mauritanians, Gætulians, Garamantes, Melano-Gætulians, Nigritæ, Cyrenaica, Marmarica, the Regio Syrtica, Turks, Tartars, and Moguls, Indians, and Chinese, a dissertation on the peopling of America, and one on the independency of the Arabs.

In the year 1740, Mr Swinton was involved in a law suit, in consequence of a letter he had published. It appears from a paper of the time *, that a letter from the Rev. Mr Swinton, highly reflecting on Mr George Baker, having fallen into the hands of the latter, the court of King's Bench made the rule absolute for an information against Mr Swinton. These two gentlemen were also engaged for some time in a controversy at Oxford; which took its rise from a matter relative to Dr Thistlethwaite, some time warden of Wadham, which then attracted much attention. Mr Swinton had the manners, and some of the peculiarities, often seen in very recluse scholars, which gave rise to many whimsical stories. Among the rest, there is one mentioned by Mr Boswell, in the Life of Johnson, as having happened in the year 1754. Johnson was then on a visit in the university of Oxford. "About this time (he says) there had been an execution of two or three criminals at Oxford, on a Monday. Soon afterwards, one day at dinner, I was saying that Mr Swinton, the chaplain of the gaol, and also a frequent preacher before the university, a learned man, but often thoughtless and absent, preached the condemnation sermon on repentance, before the convicts, on the preceding day, Sunday; and that, in the close, he told his audience, that he should give them the remainder of what he had to say on the subject the next Lord's day. Upon which, one of our company, a doctor of divinity, and a plain matter-of-fact man, by way of offering an apology for Mr Swinton, gravely remarked, that he had probably preached the same sermon before the university. Yes, Sir (says Johnson); but the university were not to be hanged the next morning!

* *The Champions, or Evening Advertiser*, June 17th 1740.

TACQUET

T.

TACQUET (Andrew), a Jesuit of Antwerp, who died in 1660. He was a moſt laborious and voluminous writer in mathematics. His works were collected, and printed at Antwerp, in one large volume in folio, 1669.

TALLOW-Tree. See Croton (*Encycl.*), where, however, we have fallen into a miſtake, which it is here our duty to correct. We learn from Sir George Staunton, that the candles made of the vegetable tallow are firmer than thoſe made of animal tallow, and free from all offenſive ſmell, contrary to what was raſhly ſaid in the article referred to. They are not, however, equal to thoſe of wax or ſpermaceti; but the latter of theſe ſubſtances is not within the reach of the Chineſe, and the art of blanching the former is little known to them. The tallow tree is ſaid to have been tranſplanted to Carolina, and to flouriſh there as well as in China.

TALOOK, an Arabic word, which ſignifies literally attachment, connection, dependence. In Bengal, however, where it occurs perpetually in the enumeration of the diſtricts, and ſubdiviſions of that province contained in the inſtitutes of Akber, it ſignifies a tenure of land. Hence the *talook* of Caſhinat, the *talook* of Meheys the headman, the *talook* of Ahmed Khan, &c. See *A Diſſertation concerning the Landed Property of Bengal*, by Sir Charles Rouſe Boughton.

TALOOKDAR, the poſſeſſor of a talook.

TALOOKDARY, tenure of a talookdar.

TALUS, or Talud, in architecture, the inclination or ſlope of a work; as of the outſide of a wall, when its thickneſs is diminiſhed by degrees, as it riſes in height, to make it the firmer.

Talus, in fortification, means alſo the ſlope of a work, whether of earth or maſonry.

TAMASCAL, the name given in California to a kind of ſand-bath employed by the natives in the cure of the venereal diſeaſe. It is prepared by ſcooping a trench in the ſand, two feet wide, one foot deep, and of a length proportioned to the ſize of the patient; a fire is then made through the whole extent of it, as well as upon the ſand which was dug out of the hollow. When the whole is thoroughly heated, the fire is removed, and the ſand ſtirred about, that the warmth may be equally diffuſed. The ſick perſon is then ſtripped, laid down in the trench, and covered up to his chin with heated ſand. In this poſition a very profuſe ſweat ſoon breaks out, which gradually diminiſhes according as the ſand cools. The patient then riſes and bathes in the ſea, or the neareſt river. This proceſs is repeated till a complete cure is obtained. While the patient is undergoing the operation of the tamaſcal, he drinks a conſiderable quantity of a warm ſudorific, prepared by the decoction of certain herbs, chiefly of the ſhrub called by the Spaniards Gouvernante, which ſee in this *Supplement*.

TAN is a ſubſtance found in moſt vegetables, which not having hitherto been reſolved into component parts, is therefore conſidered as ſimple. See *Vegetable and Animal Substances* in this *Suppl.*

TANNING is an art, of which a full account, according to the general practice in London and its vicinity, has been given under the proper title in the *Encyclopædia*. But ſince that article was written, the ſuperior knowledge which has been obtained of the tanning principal, as well as of the compoſition of the ſkins of animals (See *Vegetable and Animal Substances, Suppl.*), has ſuggeſted to ſcientific artiſts various methods of ſhortening the proceſs by which leather is manufactured. M. Seguin is ſaid to have thrown much light upon the art of the tanner as it is practiſed in France; and in 1795 Mr William Deſmond obtained a patent for practiſing Seguin's method in England. He obtains the tanning principle by digeſting oak bark, or other proper material, in cold water, in an apparatus nearly ſimilar to that uſed in the ſaltpetre works. That is to ſay, the water which has remained upon the powdered bark for a certain time, in one veſſel, is drawn off by a cock, and poured upon freſh tan. This is again to be drawn off, and poured upon other freſh tan; and in this way the proceſs is to be continued to the fifth veſſel. The liquor is then highly coloured, and marks, as Mr Deſmond ſays, from ſix to eight degrees on the hydrometer for ſalts. He calls this the tanning lixivium. The criterion to diſtinguiſh its preſence is, that it precipitates glue from its aqueous ſolution, and is alſo uſeful to examine how far other vegetable ſubſtances, as well as oak bark, may be ſuitable to the purpoſe of tanning. The ſtrong tanning liquor is to be kept by itſelf. It is found by trials with the glue, that the tanning principle of the firſt digeſter which receives the clear water, is, of courſe, firſt exhauſted. But the ſame tan will ſtill give a certain portion of the aſtringent principle, or gallic lixivium, to water. The preſence of this principle is aſcertained by its ſtriking a black colour when added to a ſmall quantity of the ſolution of vitriol of iron or green copperas. As ſoon as the water from the digeſter ceaſes to exhibit this ſign, the tan is exhauſted, and muſt be replaced with new. The gallic lixivium is reſerved for the purpoſe of taking the hair off from hides.

Strong hides, after waſhing, cleaning, and fleſhing, in the uſual way, are to be immerſed for two or three days in a mixture of gallic lixivium and one thouſandth part by meaſure of denſe vitriolic acid. By this means the hair is detached from the hides, ſo that it may be ſcraped off with a round knife. When ſwelling or raiſing is required, the hides are to be immerſed for ten or twelve hours in another vat filled with water and one five-hundredth part of the ſame vitriolic acid. The hides being then repeatedly waſhed and dreſſed, are ready for tanning; for which purpoſe they are to be immerſed for ſome hours in a weak tanning lixivium of only one or two degrees; to obtain which, the latter portions of the infuſions are ſet apart; or elſe ſome of that which has been partly exhauſted by uſe in tanning. The hides are then to be put into a ſtronger lixivium, where in a few days they will be brought to the ſame degree of ſaturation with the liquor in which they are immerſed. The ſtrength of the liquor will by this means be conſiderably diminiſhed, and muſt therefore be renewed. When the hides are by this means completely ſaturated, that is to ſay, perfectly tanned, they are to be removed, and ſlowly dried in the ſhade.

Calf ſkins, goat ſkins, and the like, are to be ſteeped

Tanning, Taffie.

in lime-water after the ufual flefhing and wafhing. Thefe are to remain in the lime water, which contains more lime than it can diffolve, and requires to be ftirred feveral times a-day. After two or three days, the fkins are to be removed, and perfectly cleared of their lime by wafhing and preffing in water. The tanning procefs is then to be accomplifhed in the fame manner as for the ftrong hides, but the lixivium muft be confiderably weaker. Mr Defmond remarks, that lime is ufed inftead of the gallic lixivium for fuch hides as are required to have a clofe grain: becaufe the acid mixed with that lixivium always fwells the fkins more or lefs; but that it cannot with the fame convenience be ufed with thick fkins, on account of the confiderable labour required to clear them of the lime; any part of which, if left, would render them harfh and liable to crack. He recommends, likewife, as the beft method to bring the whole furface of the hides in contact with the lixivium, that they fhould be fufpended vertically in the fluid by means of tranfverfe rods or bars, at fuch a diftance as not to touch each other. By this practice much of the labour of turning and handling may be faved.

Mr Defmond concludes his fpecification, by obferving, that in fome cafes it will be expedient to mix frefh tan with the lixivium; and that various modifications of ftrength, and other circumftances, will prefent themfelves to the operator. He affirms that, in addition to the great faving of time and labour in this method, the leather, being more completely tanned, will weigh heavier, wear better, and be lefs fufceptible of moifture than leather tanned in the ufual way; that cords, ropes, and cables, made of hemp or fpeartery, impregnated with the tanning principle, will fupport much greater weights without breaking, be lefs liable to be worn out by friction, and will run more fmoothly on pulleys; infomuch that, in his opinion, it will render the ufe of tar in many cafes, particularly in the rigging of fhips, unneceffary; and, laftly, that it may be fubftituted for the prefervation of animal food inftead of falt.

Mr Nicholfon, from whofe Philofophical Journal we have taken this account of Mr Defmond's method of tanning, made fome very proper enquiries at one of the firft manufacturing houfes in the borough of Southwark, concerning its value. He was told by one of the partners, that the principle upon which the new procefs is founded had been long known to them; but that they preferred the old and flower method, becaufe the hides are found to feed and improve in their quality by remaining in the pit. He could gain no fatisfactory information of what is meant by this feeding and improving; and, without taking upon us to decide between the advantages peculiar to Defmond's method and thofe of the common practice, we cannot help faying that this objection of the tanner at Southwark appears to us to be that of a man who either underftands not the principles of his own art, or has fome reafon for oppofing the progrefs of improvement, if it do not originate in his own houfe.

TASSIE (James) modeller, whofe hiftory is intimately connected with a branch of the fine arts in Britain, was born in the neighbourhood of Glafgow of obfcure parents: and began his life as a country ftone-mafon, without the expectation of ever rifing higher. Going to Glafgow on a fair day, to enjoy himfelf with his companions, at the time when the Foulis's were attempting to eftablifh an academy for the fine arts in that city, he faw their collection of paintings, and felt an irrefiftible impulfe to become a painter. He removed to Glafgow; and in the academy acquired a knowledge of drawing, which unfolded and improved his natural tafte. He was frugal, induftrious, and perfevering; but he was poor, and was under the neceffity of devoting himfelf to ftone-cutting for his fupport: not without the hopes that he might one day be a ftatuary if he could not be a painter. Reforting to Dublin for employment, he became known to Dr Quin, who was amufing himfelf in his leifure hours with endeavouring to imitate the precious ftones in coloured paftes, and take accurate impreffions of the engravings that were on them.

That art was known to the ancients; and many fpecimens from them are now in the cabinets of the curious. It feems to have been loft in the middle ages; was revived in Italy under Leo X. and the Medici family at Florence; became more perfect in France under the regency of the Duke of Orleans, by his labours and thofe of Homberg. By thofe whom they inftructed as affiftants in the laboratory it continued to be practifed in Paris, and was carried to Rome. Their art was kept a fecret, and their collections were fmall. It is owing to Quin and to Taffie that it has been carried to fuch high perfection in Britain, and attracted the attention of Europe.

Dr Quin, in looking out for an affiftant, foon difcovered Taffie to be one in whom he could place perfect confidence. He was endowed with fine tafte: he was modeft and unaffuming: he was patient; and poffeffed the higheft integrity. The Doctor committed his laboratory and experiments to his care. The affociates were fully fuccefsful; and found themfelves able to imitate all the gems, and take accurate impreffions of the engravings.

As the Doctor had followed the fubject only for his amufement, when the difcovery was completed, he encouraged Mr Taffie to repair to London, and to devote himfelf to the preparation and fale of thofe paftes as his profeffion.

In 1766 he arrived in the Capital. But he was diffident and modeft to excefs; very unfit to introduce himfelf to the attention of perfons of rank and of affluence: befides, the number of engraved gems in Britain was fmall; and thofe few were little noticed. He long ftruggled under difficulties which would have difcouraged any one who was not poffeffed of the greateft patience, and the warmeft attachment to the fubject. He gradually emerged from obfcurity, obtained competence; and what to him was much more, he was able to increafe his collection, and add higher degrees of perfection to his art. His name foon became refpected, and the firft cabinets in Europe were open for his ufe; and he uniformly preferved the greateft attention to the exactnefs of the imitation and accuracy of the engraving, fo that many of his paftes were fold on the Continent by the fraudulent for real gems. His fine tafte led him to be peculiarly careful of the impreffion; and he uniformly deftroyed thofe with which he was in the leaft diffatisfied. The art has been practifed of late by others; and many thoufands of paftes have been fold as Taffie's, which he would have confidered as injurious to his fame. Of the fame of others he was not envious; for he uniformly fpake with franknefs in praife of thofe who executed them well, though they were endeavouring to rival himfelf.

To

To the ancient engravings he added a numerous collection of the moft eminent modern ones; many of which approach in excellence of workmanfhip, if not in fimplicity of defign and chaftity of expreffion, to the moft celebrated of the ancient. Many years before he died he executed a commiffion for the late Emprefs of Ruffia, confifting of about 15,000 different engravings (See Gem, *Encycl.*). At his death, in 1799, they amounted to near 20,000; a collection of engravings unequalled in the world. Every lover of the fine arts muft be fenfible of the advantage of it for improvement in knowledge and in tafte. The collection of Feloix at Paris confifted of 1800 articles; and that of Dehn at Rome of 2500.

For a number of years, Mr Taffie practifed the modelling of portaits in wax, which he afterwards moulded and caft in pafte. By this, the exact likenefs of many eminent men of the prefent age will be tranfmitted to pofterity as accurately as thofe of the philofophers and great men have been by the ancient ftatuaries. In taking likeneffes he was, in general, uncommonly happy; and it is remarkable, that he believed there was a certain kind of infpiration (like that mentioned by the poets) neceffary to give him full fuccefs. The writer of this article, in converfing with him repeatedly on the fubject, always found him fully perfuaded of it. He mentioned many inftances in which he had been directed by it; and even fome, in which, after he had laboured in vain to realize his ideas on the wax, he had been able, by a fudden flafh of imagination, to pleafe himfelf in the likenefs feveral days after he had laft feen the original.

He poffeffed alfo an uncommonly fine tafte in architecture, and would have been eminent in that branch if he had followed it.

In private life Mr Taffie was univerfally efteemed for his uniform piety, and for the fimplicity, the modefty, and benevolence, that fhone in the whole of his character.

TASTELESS Earth (*aguft erde*), the name given by Profeffor Trommfdorff to a new fimple earth, which he difcovered in the Saxon beryl. It is diftinguifhed (he fays) from other earths by the following properties: It is white, and totally infoluble in water. In a frefh ftate, when moiftened with water, it is fomewhat ductile. In the fire it becomes tranfparent and very hard, fo as to fcratch glafs, but remains infipid and infoluble in water. The burnt earth diffolves very eafily in acids, and produces with them peculiar falts, which are entirely devoid of tafte; and hence he gave it the name of *taftelefs earth*. Fixed alkalies do not diffolve this earth either in the dry or in the wet way; and it is equally infoluble with the carbonic acid and with cauftic ammonia. It has a greater affinity to the oxalic than to other acids. Profeffor Trommfdorff informs us, that a full account of this earth, accompanied with an accurate defcription, by Dr Bernhardi, of the foffil in which it is found, will appear in the firft part of the eighth volume of his *Journal of Pharmacy*.

TEETH, of various forts of machines, as of mill wheels, &c. Thefe are often called cogs by the workmen; and by working in the pinions, rounds or trundles, the wheels are made to turn one another. Mr Emerfon (in his Mechanics, prop. 25.) treats of the theory of teeth, and fhews that they ought to have the figure of epicycloids, for properly working in one another.

TEKAWY, in Bengal, money advanced by government to the proprietors or cultivators of land to affift them under circumftances of diftrefs.

TELESCOPE, is an inftrument which has been fo completely defcribed in the *Encyclopædia*, that it is introduced into this place merely to notice an ingenious fuggeftion of Mr Nicholfon's for improving the achromatic telefcope, by adding an artificial iris to the object glafs. Suppofe (fays he) a brafs ring to furround the object end of the telefcope, and upon this let eight or more triangular flips of brafs be fixed, fo as to revolve on equi-diftant pins paffing through each triangle near one of its corners. If the triangles be flided inwards upon each other, it may readily be apprehended that they will clofe the aperture; and if they be all made to revolve or flide backwards alike, it is clear that their edges will leave an octagonal aperture, greater or lefs according to circumftances. The equable motion of all the triangles may be produced either by pinions and one concave toothed wheel, or by what is called fnail-work. Another kind of iris, more compact, may be made, by caufing thin elaftic flips of brafs to flide along parallel to the tube, and be conducted each through a flit in a brafs cap which fhall lead them acrofs the aperture in a radial direction. It is probable alfo that the artift, who fhall carry thefe hints into effect, may alfo think of feveral other methods.

This thought occurred to the author, from contemplating the contraction and dilatation of the iris of the eye, according as we look at an object more or lefs luminous. Thefe variations are fo great, that in the obfervable variations of the human eye, the aperture is thirty times as large at one time as at another, whilft in the cat the proportion is greater than a hundred to one.

TEMPERAMENT of the scale of music. Introduction.

When the confiderate reader reflects on the large and almoft numberlefs differtations on this fubject, by the moft eminent philofophers, mathematicians, and artifts, both of ancient and modern times, and the important points which divided, and ftill divide, their opinions, he will not furely expect, in a Work like our's, the decifion of a queftion which has hitherto eluded their refearches. He will rather be difpofed, perhaps, to wonder how a fubject of this nature ever acquired fuch importance in the minds of perfons of acknowledged talents (for furely no perfon will refufe this claim to Pythagoras, to Ariftotle, Euclid, Ptolemy, Galileo, Wallis, Euler, and many others, who have written elaborate treatifes on the fubject); and his furprife will increafe, when he knows that the treatifes on the fcale of mufic are as numerous and voluminous in China, without any appearance of their being borrowed from the ingenious and fpeculative Greeks.

The ingenious, in all cultivated nations, have remarked the great influence of mufic; and they found no difficulty in perfuading the nations that it was a gift of the gods. Apollo and his facred choir are perhaps the moft refpectable inhabitants of the mythological heavens of the Greeks. Therefore all nations have confidered mufic as a proper part of their religious worfhip. We doubt not but that they found it fit for exciting or fupporting thofe emotions and fentiments which were fuited to adoration, thanks, or petition. Nor would the Greeks have admitted mufic into their ferious dramas, if they had not perceived that it heightened the effect.

Temperament of the Scale of Muſic.

The ſame experience made them employ it as an aid to military enthuſiaſm; and it is recorded as one of the reſpectable accompliſhments of Epaminondas, that he had the muſical inſtructions of the firſt maſters, and was eminent as a performer.

Thus was the ſtudy of muſic ennobled, and recommended to the attention of the greateſt philoſophers. Its cultivation was held an object of national concern, and its profeſſors were not allowed to corrupt it in order to gratify the faſtidious taſte of the luxurious or the ſenſualiſt, who ſought from it nothing but amuſement. But its influence was not confined to theſe public purpoſes; and, while the men of ſpeculation found in muſic an inexhauſtible fund of employment for their genius and penetration, and their poets felt its aid in their compoſitions, it was hailed by perſons of all ranks as the ſoother of the cares and anxieties, and ſweetener of the labours of life. *O Phœbe decus!—laborum dulce lenimen.* Poor Ovid, the victim of what remained of good in the cold heart of Octavius, found its balm.

Exul eram (ſays he): *requieſque mihi, non fama petita eſt.*
Mens intenta ſuis ne foret uſque malis.
Hoc eſt cur cantet vinctus quoque compede foſſor,
Indocili numero cum grave mollit opus.
Cantet et innitens limoſæ pronus arenæ
Adverſo tardam qui trahit amne ratem,
Quique ferens pariter lentos ad pectora remos,
In numerum pulſâ brachia verſat aquâ.
Feſſus ut incubuit baculo, ſaxove reſedit
Paſtor; arundineo carmine mulcet oves.
Cantantis pariter, pariter data penſa trahentis
Fallitur ancillæ, decipiturque labor.

2 Scale of muſic. It requires temperament.

It is chiefly in this humble department of muſical influence that we propoſe at preſent to lend our aid. What has been ſaid in the article Music, *Encycl.* is ſufficient for informing the reader of what is received as the ſcale of muſic, and the inequality of its different ſteps, the tones major and minor, ſemitone, comma, &c. We ſhall only obſerve, that what is there delivered on temperament by M. d'Alembert, after Rameau, bears the evident mark of uncertainty or want of confidence in the principle adopted as the rule of temperament; and we have learned, ſince the printing of that article, that the inſtructions there delivered have not that perſpicuity and preciſion that are neceſſary for enabling a perſon to execute the temperament recommended by Rameau; that is, to tune a keyed inſtrument with certainty, according to that ſyſtem or conſtruction of the ſcale.

If ſuch be the caſe, we are in ſome meaſure diſappointed; becauſe we ſelected that treatiſe of D'Alembert as the performance of a man of great eminence as a mathematician and philoſopher, aiming at public inſtruction more than his own fame, by this elementary abſtract of the great work of the moſt eminent muſician in France.

Few can tune a harpſichord;

To be able to tune a harpſichord with certainty and accuracy, ſeems an indiſpenſable qualification of any perſon worthy of the name of a *muſician.* It would certainly be thought an unpardonable deficiency in a violin performer if he could not tune his inſtrument; yet we are well informed, that many profeſſional performers on the harpſichord cannot do it, or cannot do it any other way than by uncertain and painful trial, and, as it were, groping in the dark; and that the tuning of harpſichords and organs is committed entirely to tuners by profeſſion. This is a great inconvenience to perſons reſiding in the country; and therefore many take leſſons from the profeſſed harpſichord tuners, who alſo profeſs to teach this art. We have been preſent during ſome of theſe leſſons; but it did not appear to us that the inſtructions were ſuch as could enable the ſcholar to tune an inſtrument when alone, unleſs the leſſons had been ſo frequent as to form the ear to an inſtantaneous judgment of tune by the ſame habit that had inſtructed the teacher. There ſeemed to be little principle that could be treaſured up and recollected when wanted.

3 Yet Nature furniſhes abundant means of doing this.

Yet we cannot help thinking that there are phenomena or facts in muſic, ſufficiently preciſe to furniſh principles of abſolute certainty for enabling us to produce temperaments of the ſcale which ſhall have determined characters, and among which we may chooſe ſuch a one as ſhall be preferable to the others, according to the purpoſes we have in view; and we think that theſe principles are of ſuch eaſy application, that any perſon, of a moderate ſenſibility to juſt intonation, may, without much knowledge or practice in muſic, tune his harpſichord with all deſirable accuracy. We propoſe to lay theſe before the reader. We might content ourſelves with ſimply giving the practical rules deduced from the principles; but it is ſurely more deſirable to perceive the validity of the principles. This will give us confidence in the deduced rules of practice. In the employment of ſacred muſic, an inſpired writer counſels us to ſing, not only "with the heart, but with the underſtanding alſo." We may, without irreverence, recommend the ſame thing here. Let us therefore attend a little to the dictate of untutored Nature, and ſee how ſhe teaches all mankind to form the ſcale of melody.

4 All nations ſing by one ſcale.

It is a moſt remarkable fact, that, in all nations, however they may differ in the ſtructure of that chaunt which we call the accent, or tone, or twang, in the colloquial language of a particular nation, or in the favourite phraſes or paſſages which are moſt frequent in their ſongs, all men make uſe of the ſame riſes and falls, or inflections of voice, in their muſical language or airs. We have heard the ſongs of the Iroquois, the Cherokee, and the Eſquimaux, of the Carib, and the inhabitant of Paraguay; of the African of Negroland and of the Cape, and of the Hindoo, the Malay, and the native of Otaheite—and we found none that made uſe of a different ſcale from our own, although ſeveral ſeemed to be very ſorry performers by any ſcale. There muſt be ſome natural foundation for this uniformity. We may never diſcover this; but we may be fortunate enough to diſcover facts in the phenomena of ſound which invariably accompany certain modifications of muſical ſentiment. If we ſucceed, we are intitled to ſuppoſe that ſuch inſeparable companions are naturally connected; and to conclude, that if we can inſure the appearance of thoſe facts in ſound, we ſhall alſo give occaſion to thoſe muſical ſentiments or impreſſions.

5 Muſical pitch, what?

There is a quality in lengthened or continued ſound which we call its pitch or note, by which it may be accounted ſhrill or hoarſe. It may be very hoarſe in the beginning, and during its continuance it may grow more and more ſhrill by imperceptible gradations. In this caſe we are ſenſible of a kind of progreſs from the one

Temperament of the Scale of Muſic.

one ſtate of ſound to the other. Thus, while we gently draw the bow acroſs the ſtring of a baſs viol, if we at the ſame time ſlide the finger ſlowly along the ſtring, from the nut toward the bridge, the ſound, from being hoarſe, becomes gradually acute or ſhrill. Hoarſe and ſhrill therefore are not different qualities, although they have different names, but are different ſtates or degrees of the ſame quality, like cold and heat, near and far, early and late, or, what is common to all theſe, little and great. A certain ſtate of the air is accounted neither hot nor cold. All ſtates on one ſide of this are called warm, or hot; and all on the other are cold. In like manner, a certain ſound is the boundary between thoſe that are called hoarſe and thoſe called ſhrill. The chemiſt is accuſtomed to ſay, that the temperature of a body is higher when it is warmer, and lower when colder. In like manner, we are accuſtomed to ſay, that a perſon raiſes or depreſſes the pitch of his voice when it becomes more ſhrill or more hoarſe. The ancient Greeks, however, called the ſhriller ſounds *low*, and the hoarſer ſounds *high*; probably becauſe the hoarſer ſounds are generally ſtronger or louder, which we are alſo accuſtomed to conſider as higher. In common language, a low pitch of voice means a faint ſound, but in muſical language it means a hoarſer ſound. The ſound that is neither hoarſe nor ſhrill is ſome ordinary pitch of voice, but without any preciſe criterion.

6. The change obſerved in the pitch of a violin ſtring, when the finger is carried along the finger-board with a continued motion, is alſo continuous; that is, not by ſtarts: we call it gradual, for want of a better term, although gradual properly means *gradatim*, by degrees, ſteps, or ſtarts, which are not to be diſtinguiſhed in this experiment. But we may make the experiment in another way. After ſounding the open ſtring, and while the bow is yet moving acroſs it, we may put down the finger about $1\frac{2}{3}$ inches from the nut. This will change the ſound into one which is *ſenſibly* ſhriller than the former, and there is a manifeſt ſtart from the one to the other. Or we may put down the finger $2\frac{1}{2}$ inches from the nut; the ſound of the open ſtring will change to a ſhriller ſound, and we are ſenſible that this change or ſtep is greater than the former. Moreover, we may, while drawing the bow acroſs the ſtring, put down one finger at $1\frac{2}{3}$ inches, and, immediately after, put down another finger at $2\frac{1}{2}$ inches from the nut. We ſhall have three ſounds in ſucceſſion, each more ſhrill than the preceding, with two manifeſt ſteps, or ſubſultory changes of pitch.

7. Now ſince the laſt ſound is the ſame as if the ſecond had not been ſounded, we muſt conceive the ſum of the two ſucceſſive changes as equivalent or equal to the change from the firſt to the third. This change ſeems ſomehow to include the other two, and to be made up of them, as a whole is made up of its parts, or as $2\frac{1}{2}$ inches are made up of $1\frac{2}{3}$ and $\frac{5}{6}$ of an inch, or as the ſum 15 is made up of 10 and 5.

8

We have a notion of ſomething like an interval between the notes of muſic.

Thus it happens that thinking perſons conceive ſomething like or analogous to a diſtance, or interval, between theſe ſounds. It is plain, however, that there can be no real diſtance or ſpace interpoſed between them; and it is not eaſy to acquire a diſtinct notion of the bulk or magnitude of theſe intervals. This conception is purely figurative and analogical; but the analogy is very good, and the obſervation of it, or conjecture about it, has been of great ſervice in the ſcience of muſic, by making us ſearch for ſome preciſe meaſure of thoſe manifeſt intervals of muſical ſounds.

Temperament of the Scale of Muſic.

It muſt now be remarked, that it is in this reſpect alone that ſounds are ſuſceptible of muſic. Nor are all ſounds poſſeſſed of this quality. The ſmack of a whip, the exploſion of a muſket, the ruſhing of water or wind, the ſcream of ſome animals, and many other ſounds, both momentary and continuous, are mere noiſes; and can neither be called hoarſe nor ſhrill. But, on the other hand, many ſounds, which differ in a thouſand circumſtances of loudneſs, ſmoothneſs, mellowneſs, &c. which make them pleaſant or diſagreeable, have this quality of muſical pitch, and may thus be compared. The voice of a man or woman, the ſound of a pipe, a bell, a ſtring, the voice of an animal, nay, the ſingle blow on an empty caſk—may all have one pitch, or we may be ſenſible of the interval between them. We can, in all caſes, tighten or ſlacken the ſtring of a violin, till the moſt uninformed hearer can pronounce with certainty that the pitch is the ſame. We are indebted to the celebrated Galileo for the diſcovery of that phyſical circumſtance in all thoſe ſounds which communicates this remarkable quality to them, and even enables us to induce it on any noiſe whatever, and to determine, with the utmoſt preciſion, the muſical pitch of the ſound, and the interval between any two ſuch ſounds. Of this we ſhall ſpeak fully hereafter; and at preſent we only obſerve, that two ſounds, having the ſame pitch, are called UNISONS by muſicians, or are ſaid to be in *uniſon* to one another. 9.

When two untaught men attempt to ſing the ſame air together, they always ſing in uniſon, unleſs they expreſsly mean to ſing in different pitches of voice. Nay, it is an extremely difficult thing to do otherwiſe, except in a few very peculiar caſes. Alſo, when a man and woman, wholly uninſtructed in muſic, attempt to ſing the ſame air, they alſo *mean* to ſing the ſame muſical notes through the whole air; and they generally imagine that they do ſo. But there is a manifeſt difference in the ſounds which they utter, and the woman is ſaid to ſing more SHRILL, and the man more HOARSE. A very plain experiment, however, will convince them that they are miſtaken. *N. B.* We are now ſuppoſing that the performers have ſo much of a muſical ear, and flexible voice, as to be able to ſing a common ballad, or a pſalm tune, with tolerable exactneſs, and that they can prolong or dwell upon any particular note when deſired. 10.

Let them ſing the common pſalm tune called St David's, in the ſame way that they practiſe at church; and when they have done it two or three times, in order to fix their voices in tune, and to feel the general impreſſion of the tune, let the woman hold on in the firſt note of the tune, which we ſuppoſe to be *g*, while the man ſings the firſt three in ſucceſſion, namely *g*, *d*, *g*. He will now perceive, that the laſt note ſung by himſelf is the ſame with that ſung by the woman, and which ſhe thinks that ſhe is ſtill holding on in the firſt note of the tune. Let this be repeated till the performance becomes eaſy. They will then perceive the perfect ſameneſs, in reſpect of muſical pitch, of the woman's firſt note of this tune and the man's third note. Some difference, however, will ſtill be perceived; but it will not be in the pitch, but in the ſmoothneſs, or clearneſs, or other agreeable quality of the woman's note.

When

When this is plainly perceived, let the man try by what continued ſteps he muſt raiſe his pitch, in order to arrive at the woman's note from his own. If he is accuſtomed to common ballad ſinging, he will have no great difficulty in doing this; and will find that, beginning with his own note, and ſinging gradually up, his eighth note will be the woman's note. In ſhort, if two flutes be taken, one of which is twice as long as the other, and if the man ſing in uniſon with the large flute, the woman, while ſinging, as ſhe thinks, the ſame notes with the man, will be found to be ſinging in uniſon with the ſmaller flute.

11 There are ſeven ſteps in the natural ſcale, and eight notes.

12 OCTAVE.

This is a remarkable and moſt important fact in the phenomena of muſic. This interval, comprehending and made up of ſeven ſmaller intervals, and requiring eight ſounds to mark its ſteps, is therefore called an OCTAVE. Now, ſince the female performer follows the ſame dictates of natural ear in ſinging her tune that the man follows in ſinging his, and all hearers are ſenſible that they are ſinging the ſame tune, it neceſſarily follows, that the two ſerieſes of notes are perfectly ſimilar, though not the ſame: For there muſt be the ſame interval of an octave between any ſtep of the lower octave and the ſame ſtep of the upper one. In whatever way, therefore, we conceive one of theſe octaves to be parcelled out by the different ſteps, the partition of both muſt be ſimilar. If we repreſent both by lines, theſe lines muſt be ſimilarly divided. Each partial interval of the one muſt bear the ſame relation to the whole, or to any other interval, as its ſimilar interval in the other octave bears to the whole of that octave, or to the other correſponding interval in it.

13 All octaves are ſimilar.

Farther, we muſt now obſerve, that although this ſimilarity of the octaves was firſt obſerved or diſcovered by means of the ordinary voices of man and woman, and is a legitimate inference from the perfect ſatisfaction that each feels in ſinging what they think the ſame notes, this is not the only foundation or proof of the ſimilarity. Having acquired the knowledge of that phyſical circumſtance, on which the pitch of muſical ſounds depends, we can demonſtrate, with all the rigour of geometry, that the ſeveral notes in the man and woman's octave *muſt* have the ſame relation to their reſpective commencements, and that theſe two great intervals are ſimilarly divided. But farther ſtill, we can demonſtrate that this ſimilarity is not confined to theſe two octaves. This may even be proved, to a certain extent, by the ſame original experiment. Many men can ſing two octaves in ſucceſſion, and there are ſome rare examples of perſons who can ſing three. This is more common in the female voice. This being the caſe, it is plain that there will be two octaves common to both voices; and therefore four octaves in ſucceſſion, all ſimilar to each other. The ſame ſimilarity may be obſerved in the ſounds of inſtruments which differ only by an octave. And thus we demonſtrate that all octaves are ſimilar to each other. This ſimilarity does not conſiſt merely in the ſimilarity of its diviſion. The ſound of a note and its octave are ſo like each other, that if the ſtrength or loudneſs be properly adjuſted, and there be no difference in kind, or other circumſtances of clearneſs, ſmoothneſs, &c. the two notes, when ſounded together, are indiſtinguiſhable, and appear only like a more brilliant note. They coaleſce into one ſound. Nay, moſt clear mellow notes, ſuch as thoſe of a fine human voice, really contain each two notes, one of which is octave to the other.

We ſaid that this reſemblance of octaves is an important fact in the ſcience of muſic. We now ſee why it is ſo. The whole ſcale of muſic is contained in one octave, and all the reſt are only repetitions of this ſcale. And thus is the doctrine of the ſcale of melody brought within a very moderate compaſs, and the problem is reduced to that of the repartition of a ſingle octave, and ſome attention to the junction with the ſimilar ſcales of the adjoining octaves. This partition is now to be the ſubject of diſcuſſion.

14 All muſic contained in the octave; hence called DIAPASON.

15 Melodies, or tunes, or airs, were the firſt muſic.

In the infancy of ſociety and cultivation, it is probable that the melodies or tunes, which delighted the ſimple inhabitants, were equally ſimple. Being the ſpontaneous effuſions of individuals, perhaps only occaſional, and never repeated, they would periſh as faſt as produced. The airs were probably connected with ſome of the rude rhimes, or gingles of words, which were banded about at their feſtivals; or they were aſſociated with dancing. In all theſe caſes they muſt have been very ſhort, conſiſting of a few favourite paſſages or muſical phraſes. This is the caſe with the common airs of all ſimple people to this day. They ſeldom extend beyond a ſhort ſtanza of poetry, or a ſhort movement of dancing. The artiſt who could compoſe and keep in mind a piece of conſiderable length, muſt have been a great rarity, and a minſtrel fit for the entertainment of princes; and therefore much admired, and highly rewarded: his excellencies were almoſt incommunicable, and could not be preſerved in any other way but by repeated performance to an attentive hearer, who muſt alſo be an artiſt, and muſt patiently liſten, and try to imitate; or, in ſhort, to get the tune by heart. It muſt have been a long time before any diſtinct notion was formed of the relation of the notes to each other. It was perhaps impoſſible to recollect today the preciſe notes of yeſterday. There was nothing in which they were fixed till inſtrumental muſic was invented. This has been found in all nations; but it appears that long continued cultivation is neceſſary for raiſing this from a very ſimple and imperfect ſtate. The moſt refined inſtrument of the Greek muſicians was very far below our very ordinary inſtruments. And, till ſome method of notation was invented, we can ſcarcely conceive how any determined partition of the octave could be made generally known.

16 KEY-NOTE or FUNDAMENTAL.

Accordingly, we find that it was not till after a long while, and by very rude and awkward ſteps, that the Greeks perceived that the whole of muſic was compriſed in the octave. The firſt improved lyre had but four ſtrings, and was therefore called a TETRACHORD; and the firſt flutes had but three holes, and four notes; and when more were added to the ſcale, it was done by joining two lyres and two flutes together. Even this is an inſtructive ſtep in the hiſtory of muſical ſcience: For the four ſounds of the inſtrument have a natural ſyſtem, and the awkward and groping attempts to extend the muſic, by joining two inſtruments, the ſcale of the one following, or being a continuation of that of the other, pointed out the DIAPASON or *totality* of the octave, and the relation of the whole to a principal ſound, which we now call the *fundamental* or *key*, it being the loweſt note of our ſcale, and the one to which the other notes bear a continual reference. It would far exceed the

limits

Tempera-ment of the Scale of Muſic.

limits of this Work to narrate the ſucceſſive changes and additions made by the Greeks in their lyre; yet would this be a very ſure way of learning the natural formation of our muſical ſcale. We muſt refer our readers to Dr Wallis's Appendix to his edition of the Commentary of Porphyrius in Ptolemy's Harmonics, as by far the moſt perſpicuous account that is extant of the Greek muſic. We ſhall pick out from among their different attempts ſuch plain obſervations as will be obvious to the feelings of any perſon who can ſing a common tune.

17
The octave is naturally divided into two TETRACHORDS.

Let ſuch a perſon firſt ſing over ſome plain and cheerful, or at leaſt not mournful, tune, ſeveral times, ſo as to retain a laſting impreſſion of the chief note of the tune, which is generally the laſt. Then let him begin, on the ſame note, to ſing in ſucceſſion the riſing ſteps of the ſcale, pronouncing the ſyllables *do*, *re*, *mi*, *fa*, *ſol*, *la*, *ſi*, *do*. He will perhaps obſerve, that this chaunt naturally divides itſelf into two parts or phraſes, as the muſicians term it. If he does not, of himſelf, make this remark, let him ſing it, however, in that manner, pauſing a little after the note *fa*. Thus, *do*, *re*, *mi*, *fa*; *ſol*, *la*, *ſi*, *do*.—*Do*, *re*, *mi*, *fa*; *ſol*, *la*, *ſi*, *do*.

Having done this ſeveral times, and then repeated it without a pauſe, he will become very ſenſible of the propriety of the pauſe, and of this natural diviſion of the octave. He will even obſerve a conſiderable ſimilarity between theſe two muſical phraſes, without being able, at firſt, to ſay in what it conſiſts.

18
The ſteps of the ſcales are unequal, and the two tetrachords are ſimilar.

Let him now ſtudy each phraſe apart, and try to compare the magnitude of the changes of ſound; or ſteps which he makes in riſing from *do* to *re*, from *re* to *mi*, and from *mi* to *fa*. We apprehend that he will have no difficulty in perceiving, after a few trials, that the ſteps *do re*, and *re mi*, are ſenſibly greater than the ſtep *mi fa*. We feel the laſt ſtep as a ſort of ſlide; as an attempt to make as little change of pitch as we can. Once this is perceived, it will never be forgotten. This will be ſtill more clearly perceived, if, inſtead of theſe ſyllables, he uſe only the vowel *a*, pronounced as in the word *hall*, and if he ſing the ſteps, ſliding or ſlurring from the one to the other. Taking this method, he cannot fail to notice the ſmallneſs of the third ſtep.

19
Let the ſinger farther conſider, whether he does not feel this phraſe muſical or agreeable, making a ſort of tune or chaunt, and ending or cloſing agreeably after this ſlide of a ſmall, or, as it were, half ſtep. It is generally thought ſo; and is therefore called a CLOSE, a CADENCE, when we end with a half ſtep aſcending.

20
Let the ſinger now reſume the whole ſcale, ſinging the four laſt notes *ſol*, *la*, *ſi*, *do*, louder than the other four, and calling off his attention from the low phraſe, and fixing it on the upper one. He will now be able to perceive that this, like the other, has two conſiderable ſteps; namely, *ſol*, *la*, and *la ſi*, and then a ſmaller ſtep, *ſi do*. A few repetitions will make this clear, and he will then be ſenſible of the nature of the ſimilarity between theſe two phraſes, and the propriety of this great diviſion of the ſcale into the intervals *do*, *fa*, and *ſol*, *do*, with an interval *fa*, *ſol* between them.

This was the foundation of the tetrachords, or lyres of four ſtrings, of the Greeks. Their earlieſt muſic or modulation ſeems to have extended no farther than this phraſe. It pleaſed them, as a ring of four bells pleaſes many country pariſhes.

21
Close of cadence.

The ſinger will perceive the ſame ſatisfaction with the cloſe of this ſecond phraſe as with that of the former: and if he now ſing them both, in immediate ſucceſſion, with a ſlight pauſe between, we imagine that he will think the cloſe or cadence on the upper *do* even more ſatisfactory than that on the *fa*. It ſeems to us to complete a tune. And this impreſſion will be greatly heightened, if another perſon, or an inſtrument, ſhould ſound the lower *do*, while he cloſes on the upper *do* its octave. *Do* ſeems to be expected, or looked for, or ſought after. We take *ſi* as a ſtep to *do*, and there we reſt.

22
The third and ſeventh ſtep are the ſmalleſt.

Thus does the octave appear to be naturally compoſed of ſeven ſteps, of which the firſt, ſecond, fourth, fifth, and ſixth, are more conſiderable, and the third and ſeventh very ſenſibly ſmaller. Having no direct meaſures of their quantity, nor even a very diſtinct notion of what we mean by their quantity, magnitude, or bulk, we cannot pronounce, with any certainty, whether the greater ſteps are equal or unequal; and we preſume them to be equal. Nor have we any diſtinct notion of the proportion between the larger and ſmaller ſteps. In a looſe way we call them half notes, or ſuppoſe the riſe from *mi* to *fa*, or from *ſi* to *do*, to be one-half of that from *do* to *re*, or from *re* to *mi*.

23
The Pythagorean diſcoveries did not improve the Greek muſic.

Accordingly, this ſeems to have been all the muſical ſcience attained by the Greek artiſts, or thoſe who did not profeſs to ſpeak philoſophically on the ſubject. And even after Pythagoras publiſhed the diſcovery which he had made, or more probably had picked up among the Chaldeans or Egyptians, by which it appeared, that accurate meaſures of ſounds, in reſpect to gravity and acuteneſs, were attainable, it was affirmed by Ariſtoxenus, a ſcholar of Ariſtotle, and other eminent philoſophers, that theſe meaſures were altogether artificial, had no connection with muſic, and that the ear alone was the judge of muſical intervals. The artiſt had no other guide in tuning his inſtrument; becauſe the ratios, which were ſaid to be inherent in the ſounds (though no perſon could ſay how), were never perceived by the ear. The juſtice of this opinion is abundantly confirmed by the awkward attempt of the Greeks to improve the lyre by means of theſe boaſted ratios. Inſtead of illuſtrating the ſubject, they ſeem rather to have brought an additional obſcurity upon it, and threw it into ſuch confuſion, that although many voluminous diſſertations were written on it, and on the compoſition of their muſical ſcale, the account is ſo perplexed and confuſed, that the firſt mathematicians and artiſts of Europe acknowledged, that the whole is an impenetrable myſtery. Had the philoſophers never meddled with it, had they allowed the practical muſicians to conſtruct and tune their inſtruments in their own way, ſo as to pleaſe their ear, it is ſcarcely poſſible that they ſhould not have hit on what they wanted, without all the embarraſſment of the chromatic and enharmonic ſcales of the lyre. It is ſcarcely poſſible to contrive a more cumberſome method of extending the ſimple ſcale of Nature to every caſe that could occur in their muſical compoſitions, than what aroſe from the employment of the muſical ratios. This ſeems a bold aſſertion; but we apprehend that it will appear to be juſt as we proceed.

24
The tranſpoſition of muſic made intercalary notes neceſſary in the octave.

The practical muſicians could not be long of finding the want of ſomething more than the mere diatonic ſcale of their inſtruments. As they were always accompanied by the voice, it would often happen that a lyre or flute, perfectly tuned, was too low or too high for

Temperament of the Scale of Mufic.

for the voice that was to accompany it. A finger can pitch his tune on any found as a key; and if this be too high for the finger who is to accompany him, he can take it on a lower note. But a lyrift cannot do this. Suppofe his inftrument two notes too low, and that his accompanyift can only fing it on the key which is the *fi* of the lyre. Should the lyrift begin it on that key, his very firft ftep is wrong, being but a half ftep, whereas it fhould be a whole one. In fhort, all the fteps but one will be found wrong, and the lyrift and finger will be perpetually jarring. This is an evident confequence of the inequality of the fourth and feventh fteps to the reft. And if the other fteps, which we imagine to be equal, be not exactly fo, the difcordance will be ftill greater.

Difputes of the Pythagoreans and Ariftoxeneans about mufical ratios.

The method of remedying this is very obvious. If the intervals *mi fa* and *fi do*, are half notes, we need only to interpofe other founds in the middle between each of the whole notes; and then, in place of feven unequal fteps, we fhall have twelve equal ones, or twelve intervals, each of them equal to a femitone. The lyre thus conftructed will now fuit any voice whatever. It will perfectly refemble our keyed inftruments, the harpfichord, or organ, which have twelve feemingly equal intervals in the octave. Accordingly, it appears that fuch additions were practifed by the muficians of Greece, and approved of by Ariftoxenus, and by all thofe who referred every thing to the judgment of the ear. And we are confident that this method would have been adopted, if the philofophers had had lefs influence, and if the Greeks had not borrowed their religious ceremonies along with their mufical fcience. Both of thefe came from the fame quarter; they came united; and it was facrilegious to attempt innovations. The doctrine of mufical ratios was an occupation only for the refined, the philofophers; and by fubjecting mufic to this myfterious fcience, it became myfterious alfo, and fo much the more venerable. The philofophers faw, that there was in Nature a certain infcrutable connection between mathematical ratios and thofe intervals which the ear relifhed and required in melody; but they were ignorant of the nature and extent of this connection.

Ratios of octave, diapente, and diateffaron.

What is this connection, or what is meant when we fpeak of the ratios of founds? Simply this:—Pythagoras is faid to have found, that if two mufical cords be ftrained by equal weights, and one of them be twice the length of the other, the fhort one will found the octave to the note of the other. If it be two-thirds of the length of the long ftring, it will found the fifth to it. If the long ftring found *do*, the fhort one will found *fol* If it be three-fourths of the length, it will found the fourth or *fa*. Thus the ratio of 2 : 1 was called the ratio of the DIAPASON; that of 3 : 2 was called the DIAPENTE; and that of 4 : 3 the DIATESSARON. Moreover, if we now take all the four ftrings, and make that which founds the graveft note, and is the longeft, twelve inches in length; the fhort or octave ftring muft be fix inches long, or one-half of twelve; the diapente muft be eight inches, or two-thirds of twelve; and the diateffaron muft be nine inches, which is three-fourths of twelve. If we now compare the diapente, not with the graveft ftring, but with the octave of fix inches, we fee that they are in the ratio of 4 to 3, or the ratio of diateffaron. And if we compare the diateffaron with the octave, we fee that their ratio is that of 9 : 6, or of 3 : 2, or the ratio of diapente. Thus is the octave divided into a fifth and a fourth, *do fol*, and *fol do*, in fucceffion. Alfo the fourth *do fa*, and the fifth *fa do*, make up the octave. The note which ftands as a fifth to one of the extreme founds of the octave, ftands as a fourth to the other. And, laftly, the two fourths *do fa*, and *fol do*, leave an interval *fa fol* between them; which is alfo determined by nature, and the ratio correfponding to it is evidently that of 9 to 8.

25 The difcovery of Pythagoras is either a fable, or falfely narrated.

This is all that was known of the connection of mufic with mathematical ratios. It is indeed faid by Iamblichus, that Pythagoras did not make this difcovery by means of ftrings, but by the founds made by the hammers on the anvil in a fmith's fhop. He obferved the founds to be the key, the diateffaron, and the diapente of mufic; and he found, that the weights of the hammers were in this proportion; and as foon as he went home, he tried the founds made by cords, when weights, in the proportions above-mentioned, were appended to them. But the whole ftory has the air of a fable, and of ignorance. The founds given by a fmith's anvil have little or no dependence on the weight of the hammers; and the weights which are in the proportions of the numbers mentioned above will by no means produce the founds alleged. It requires *four* times the weight to make a ftring found the octave, and *twice and a quarter* will produce the diapente, and *one and feven-ninths* will produce the diateffaron. It is plain, therefore, that they knew not of what they were fpeaking: yet, on this flight foundation, they erected a vaft fabric of fpeculation; and in the courfe of their refearches, thefe ratios were found to contain all that was excellent. The attributes of the Divinity, the fymmetry of the univerfe, and the principles of morality, were all refolvable into the harmonic ratios.

26 Conjoined and disjoined tetrachords.

In the attempts to explain, by means of the myfterious properties of the ratios 2 : 1, 3 : 2, 4 : 3, and 9 : 8, which were thus defined by Nature, it was obferved, that their favourite lyres of four ftrings could be combined in two principal manners, fo as to produce an extenfive fcale. One lyre may contain the notes *do, re, mi, fa*; and the acuter lyre may contain the notes *fol, la, fi, do*; and, being fet in fucceffion, having the interval *fa fol* between the higheft note of the one and the loweft of the other, they make a complete octave. Thefe were called *disjoined tetrachords*. Again, a third tetrachord may be joined with the upper tetrachord laft mentioned, in fuch fort, that the loweft note of the third tetrachord may be the fame with the higheft of the fecond. Thefe were called *conjoined* tetrachords (A).

27 The lyres were tuned entirely by the ear.

By thus confidering the fcale as made up of tetrachords, the tuning of the lyre was reduced to great fimplicity. The mufician had only to make himfelf perfect in the fhort chant *do, re, mi, fa*, or to get it by

(A) This is the *principle*, but not the precife *form*, of the disjoined and conjunct tetrachords. The Greeks did not begin the tetrachord with what we make the firft note of our chaunt of four notes, but began one of them with *mi*, and the other with *fi*; to which they afterwards added a note below. This beginning feems to have been directed by fome of their favourite cadences; but it would be tedious to explain it.

Temperament of the Scale of Music.

by heart, and to fing it exactly. This intonation would apply equally to the other *fol*, *la*, *fi*, *do*. We are well informed that this was really the practice. The directions given by Ariftoxenus, Nicanor, and others, for varying the tuning, according to certain occafional accommodations, fhew diftinctly that they did not tune as we do, founding the two ftrings together, except in the cafe of the diapafon or octave. It was all done by the judgment of the ear in melody. The moft valuable circumftance in the difcovery of Phythagoras was the determination of the interval between the fourth and the fifth, by which the tetrachords were feparated. The filling up of each tetrachord was left entirely to the ear; and when the doctrine of the mathematical ratios fhewed that the large intervals *do re*, *re mi*, *fa fol*, *fol la*, *la fi*, fhould not be precifely equal, Ariftoxenus refufed the authority of the reafons alleged for this inequality, becaufe the ear perceived none of the ratios as ratios, and could judge only of founds. He farther affeited, that the inequalities which the Pythagoreans enjoined, were fo trifling, that no ear could poffibly perceive them. And accordingly, the theorifts difputed about the refpective fituations of the greater and fmaller tones (fo they named the great fteps) fo much fpoken of, and had different fyftems on the fubject.

28 And by melody alone:

But the ftrongeft proof of the indiftinct notion that the theorifts entertained about the influence of thefe ratios in mufic is, that they would admit no more but thofe introduced by Pythagoras; and their reafons for the rejection of the ratio of 5 to 4, and of 6 to 5, were either the moft whimfical fancies about the perfections of the facred ratios, or affumptions exprefsly founded on the fuppofition, that the ear perceives and judges of the ratios as ratios; than which nothing can be more falfe. Had they admitted the ratio of 5 to 4, they would have obtained the third note of the fcale, and would at once have gotten the whole fcale of our mufic. The ratios of 6 : 5, and 16 : 15, follow of courfe; and every found of the tetrachords would have been determined. For 5 : 4 being the ratio of the major third, which is perfectly pleafing to the ear, as the *mi* to the note *do*, and 3 : 2 being the ratio of the fifth *do fol*, there is another interval *mi fol* determined; and this ratio, being the difference between *do fol* and *do mi*, or between 3 : 2 and 5 : 4, is evidently 6 : 5. In like manner, the interval *mi fa* is determined, and its ratio, being 4 : 3—5 : 4, is 16 : 15.

But farther; we fhall find, upon trial, that if we put in a found above *fol*, having the relation 5 : 4 to *fa*, it will be perfectly fatisfactory to the ear if fung as the note *la*. And if, in like manner, we put in a note above *la*, having the relation 5 : 4 to *fol*, we find it fatisfactory to the ear when ufed as *fi*. If we now examine the ratios of thefe artificial notes, we fhall find the ratio of the notes *fol la* to be 10 : 9, and that of *la fi* to be 9 : 8, the fame with that *fa fol*; alfo *fi do* will appear to be 16 : 15, like that of *mi fa*.

We have no remains of the mufic of the Greeks, by which we can learn what were their favourite paffages or mufical phrafes; and we cannot fee what caufed them to prefer the fourth to the major third. Few muficians of our times think the fourth in any degree comparable with the major third for melodioufnefs, and ftill fewer for harmonioufnefs. The piece or tune publifhed by Kircher from Alypius is very fufpicious, as no other perfon has feen the MS.; and the collection found at Buda is too much disfigured, and probably of too late a date, to give us any folid help. In all probability, the common melodies of the Greeks abounded in eafy leaps up and down on the third and fifth, and on the fourth and fixth, juft as we obferve in the airs for dancing among all fimple people. Their accomplifhed performers had certainly great powers both of invention and execution; and the chromatic and enharmonic divifions of the fcale were certainly practifed by them, and not merely the fpeculations of mathematicians. To us, the enharmonic fcale appears the moft jarring difcord; but this is certainly owing to our not feeing any pieces of the mufic fo compofed, and becaufe we cannot in the leaft judge by harmony what the effect of enharmonic melody would be. But we have fufficient evidence, from the writings of the ancient Greeks, that the enharmonic mufic fell into difufe even before the time of Ptolemy, and was totally and irrecoverably loft before the 5th century. Even the chromatic was little practifed, and was chiefly employed for extending the common fcale to keys which were feldom ufed. The uncertainties refpecting even the common fcale remained the fame as ever; and although Ptolemy gives (among others) the very fame that is now admitted as the only perfect one, namely, his *diatonicum intenfum*, his reafons of preference, though good, are not urged with ftrong marks of his confidence in them, nor do they feem to have prevailed.

These obfervations fhew clearly, that the perception of melody alone is not fufficiently precife for enabling us to acquire exact conceptions of the fcale of mufic. The whole of the practicable fcience of the ancients feems to amount to no more than this, that the octave contained five greater and two fmaller intervals, which the voice employed, and the ear relifhed. The greater intervals feemed all of one magnitude; and the fmaller intervals appeared alfo equal, but the ear cannot judge what proportion they bear to the larger ones. The muficians thought them larger than one-half of the great intervals (and indeed the ratio 16 : 15 of the artificial *mi fa* and *fi do*, is greater than the half of 9 : 8 or 10 : 9). Therefore they allowed the theorifts to call them *limmas* inftead of *hemitones*; but they, as well as the theorifts, differed exceedingly in the magnitudes which they affigned them. 29 But melody is quite infufficient.

The beft way that we can think of for expreffing the fcale of the octave is, by dividing the circumference of a circle in the points C, D, E, F, G, A, and B, (fig. 1.), in the proportion we think moft fuitable to the natural fcale of melody. According to the practical notion now under our confideration, the arches CD, DE, FG, GA, and AB, are equal, containing nearly 59°; and the arches EF and BC are alfo equal, but fmaller than the others, containing about $33\frac{1}{2}$. Now, fuppofe another circle, on a piece of card paper, divided in the fame manner, to move round their common centre, but inftead of having its points of divifion marked C, D, E, &c. let them be marked *do*, *re*, *me*, *fa*, *fol*, *la*, *fi*. It is plain, that to whatever point of the outer circle we fet the point *do* of the inner one, the other points of the outer circle will fhew the common notes which are fit for thofe fteps of the fcale. The fimilarity of all octaves makes this fimple octave equivalent to a rectilineal fcale fimilarly divided, and repeated as often 30 Circular reprefentation of the fcale Plate XLIV.

Tempera-ment of the Scale of Music.

as we pleafe. Fig. 1. reprefents this inftrument, and will be often referred to. A fort of fymmetry may be obferved in it. The point D feems to occupy the middle of the fcale, and *re* feems to be the middle note of the octave. The oppofite arch GA, and the correfponding interval *fol la*, feems to be the middle interval of the octave. The other notes and intervals are fimilarly difpofed on each fide of thefe. This circumftance feems to have been obferved by the Greeks, by the inhabitants of India, by the Chinefe, and even by the Mexicans. The note *re*, and the interval *fol la*, have gotten diftinguifhed fituations in their inftruments and fcales of mufic.

31 Ariftoxenean fcale of mean tones and limmas.

With refpect to the divifion of the circles, we fhall only obferve at prefent, that the dotted lines are conformable to the principles of Ariftoxenus, the whole octave being portioned out into five larger and equal intervals, and two fmaller, alfo equal. The larger are called *mean* or *medium tones*; and the fmaller are called *limmas* or *femitones*. The full lines, to which the letters and names are affixed, divide the octave into the artificial portions, determined by means of the mufical ratios, the arches being made proportional to the meafures of thofe ratios. Thus the arches CD, FG, AB, are proportional to the meafure or logarithm of the ratio 9 : 8; GA and DE are proportional to the logarithm of 10 : 9; and the arches EF and BC are proportional to the logarithm of 16 : 15. We have already mentioned the way in which thofe ratios were applied, and the authority on which they were felected. We fhall have occafion to return to this again. The only farther remark that is to be made with propriety in this place is, that the divifion on the Ariftoxenean principles, which is expreffed in this figure, is one of an indefinite number of the fame kind. The only principle adopted in it is, that there fhall be five mean tones, and two fmall equal femitones; but the magnitude of thefe is arbitrary. We have chofen fuch, that two mean tones are exactly equal to the arch CE, determined by the ratio 5 : 4. The reafons for this preference will appear as we proceed (B).

By this little inftrument (the invention, we believe, of a Mr D'Ormiffon, about the beginning of laft century), we fee clearly the infufficiency of the feven notes of the octave for performing mufic on different keys. Set the flower de luce at the Ariftoxenean B, and we fhall fee that E is the only note of our lyre which will do for one of the fteps of the octave in which we intend to fing and accompany. We have no founds in the lyre for *re*, *mi*, *fol*, *la*, *fi*. The remedy is as clearly pointed out. Let a fet of ftrings be made, having the fame relation to *fi* which thofe of the prefent lyre have to *do*, and infert them in the places pointed out by the Ariftoxenean divifions of the moveable octave. We need only five of them, becaufe the *fi* and *fa* of the prefent lyre will anfwer. Thefe new founds are marked by a +.

32 Found imperfect, and required TEMPERAMENT.

But it was foon found, that thefe new notes gave but indifferent melody, and that either the ear could not determine the equality of the tones and femitones exactly enough, or that no fuch partition of the octave would anfwer. The Pythagoreans, or partifans of the mufical ratios, had told them this before. But they were in no better condition themfelves; for they found, that if a feries of founds, in perfect relation to the octave, be inferted in the manner propofed, the melody will be no better. They put the matter to a very fair trial. It is eafy to fee, that no fyftem of mean tones and limmas will give the fame mufic on every key, unlefs the tones be increafed, and the limmas diminifhed, till the limma becomes juft half a tone. Then all the intervals will be perfectly equal. The mathematicians computed the ratios which would produce this equality, and defired the Ariftoxeneans to pronounce on the mufic. It is faid, that they allowed it to be very bad in all their moft favourite paffages. Nothing now remained to the Ariftoxeneans but to attempt occafional methods of tuning. They faw clearly, that they were making the notes unequal which Nature made equal. The Pythagoreans, in like manner, pointed out many alterations or corrections of intervals which fuited one tetrachord, or one part of the octave, but did not fuit another. Both parties faw that they were obliged to deviate from what they thought natural and perfect: therefore they called thefe alterations of the natural or perfect fcale *temperament*.

The accomplifhed performers were the beft judges of the whole matter, and they derived very little affiftance from the mathematicians: For although the rigid rules delivered by them be acknowledged to be perfectly exact, the execution of thofe rules is not fufceptible of the fame exactnefs. Their lyres are tuned, not by mathematical operations, but by the ear. It does not appear that they had mufical inftruments with divided finger-boards, like our bafs viols and guitars; and even on thefe, it is well known that the preffure and touch of the finger may vary fo much, that the moft exact placing of the frets will not infure the nice degrees of the founds. The flutes are the only inftruments of the ancients that are capable of accurate founds. But flutemakers know very well, that they cannot be tuned by mathematical operations, but by the ear alone. This accounts for the great prices paid for a well-tuned flute. Some have coft L. 700, and L. 50 was a very common price.

33 The Greeks did not cultivate the harmony of fimultaneous founds.

Such feems to have been the ftate of the ancient mufic. There was little or no fcience in it. There was, indeed, a moft abftrufe and refined fcience coupled with it; but by a very flight connection: and it feems to have been nothing more than an amufement for the ingenious and fpeculative Greeks. Nor could it, in our opinion, be better, fo long as they had no guide in tuning but the judgment of the ear in melody. Many writers infift that the Greeks had a knowledge of what *we* call *harmony* alfo. The word ἁρμονια is conftantly ufed by them: but it does not mean what we call harmony, the pleafant coalefcence of fimultaneous founds. It comes from ἁρμος, or from ἁρμοζω, and fignifies *aptitude*, *fitnefs*, and would, in general, be better tranflated by *fymmetry*. But we cannot conceive that they paid any marked attention to the effect of fimultaneous founds, fo as to enjoy the pleafure of certain confonances, and employ them in their compofitions. We judge in this way from the rank which they gave them in their

(B) We fhall be abundantly exact, if we make CD=61°,72; CE=115°,9; CF=149°,42; CG=210°,58; CA=265°,3; and CB=326°,48.

Tempera-ment of the Scale of Mufic.

their fcale. To prefer the fourth to the major third feems to us to be impoffible, if it be meant of fimultaneous founds. And the reafon which is affigned for the preference can have no value in the opinion of a mufician. It is becaufe the ratio of 4 : 3 is fimpler than that of 5 : 4. For the fame reafon, the fifth is preferred to both, and the octave to all the three, and unifon to every other confonance. They would not allow the major third 5 : 4 to be a concord at all. We have made numberlefs trials of the different concords with perfons altogether ignorant of mufic. We never faw an inftance of one who thought that mere unifon gave any pofitive pleafure. None of all whom we examined had much pleafure from an octave. All, without exception, were delighted with a fifth, and with a major third; and many of them preferred the latter. All of them agreed in calling the pleafure from the fifth a *fweetnefs*, and that from the major third a *cheerfulnefs*, or *fmartnefs*, or by names of fimilar import. The greater part preferred even the major fixth to the fourth, and fome felt no pleafure at all from the fourth. Few had much pleafure from the minor third or minor fixth. *N. B.* Care was taken to found thefe concords without any preparation—merely as founds—but not as making part of any mufical paffage. This circumftance has a great effect on the mind. When the minor third and fixth were heard as making part of the minor mode, all were delighted with it, and called it fweet and mournful. In like manner, the chord $\frac{6}{4}$ never failed to give pleafure. Nothing can be a ftronger proof of the ignorance of the ancients of the pleafures of harmony.

34 The pleafures of harmony feem to be modern difcovery.

We do not profefs to know when this was difcovered. We think it not unlikely that the Greeks and Italians got it from fome of the northern nations whom they called *Barbarians*. We cannot otherwife account for its prevalence through the whole of the Ruffian empire—the ancient Slavi had little commerce with the empire of Rome or of Conftantinople; yet they fung in parts in the moft remote periods of their hiftory of which we have any account; and to this day, the moft uncultivated boor in the Ruffian empire would be afhamed to fing in unifon. He liftens a little while to a new tune, holding his chin to his breaft; and as foon as he has got a notion of it, he burfts out in concert, throwing in the harmonic notes by a certain rule which he feels, but cannot explain. His harmonics are generally alternate major and minor thirds, and he feldom miffes the proper cadences on the fifth and key. Perhaps the invention of the organ produced the difcovery. We know that this was as early as the fecond century (c). It was hardly poffible to make much ufe of that inftrument without perceiving the pleafure of concordant founds.

35 Harmony made a great change in the fcience of mufic.

The difcovery of the pleafures of harmony occafioned a total change in the fcience of mufic. During the dark ages of Europe, it was cultivated chiefly by the monks: the organ was foon introduced into the churches, and the choral fervice was their chief and almoft their only occupation. The very conftruction of this inftrument muft have contributed to the improvement of mufic, and inftructed men in the nature of the fcale. The pipes are all tuned by their lengths; and thefe lengths are in the ratios of the ftrings which give the fame notes, when all are equally ftretched. This muft have revived the ftudy of the mufical ratios. The tuning of the organ was performed by confonance, and no longer depended on the nice judgment of founds in fucceffion. The dulleft ear, even with total ignorance of mufic, can judge, without the fmalleft error, of an exact octave, fifth, third, or other concord; and a very mean mufician could now tune an organ more accurately than Timotheus could tune his lyre. Other keyed inftruments, refembling our harpfichord, were invented, and inftruments with fretted finger-boards. Thefe foon fupplanted the lyres and harps, being much more compendious, and allowing a much greater variety and rapidity of modulation. All thefe inftruments were the fruits of harmony, in the modern fenfe of that word. The deficiences of the old diatonic fcale were now more apparent, and the neceffity of a number of intercalary notes. The finger-board of an organ or harpfichord, running through a feries of octaves, and admitting much more than the accompanyment of one note, pointed out new fources of mufical pleafure arifing from the fulnefs of the harmony; and, above all, the practice of choral finging fuggefted the poffibility of a pleafure altogether new. While a certain number of the choir performed the Cantus or Air of the mufic, it was irkfome to the others to utter mere founds, fupporting or compofing the harmony of the Cantus, without any melody or air in their own parts. It was thought probable that the harmonic notes might be fo portioned out among the reft of the choir, that the fucceffion of founds uttered by each individual might alfo conftitute a melody not unpleafant, and perhaps highly grateful. On trial it was found very practicable. Canons, motets, fugues, and other harmonics, were compofed, where the airs performed by the different parts were not inferior in beauty to the principal. The notes which could not be thrown into this agreeable fucceffion, were left to the organift, and by him thrown into the bafs.

By all thefe practices, the imperfections of the fcale of fixed founds became every day more fenfible, efpecially in full harmony. Scientific mufic, or the properties of the ratios, now recovered the high eftimation in which they were held by the ancient theorifts; and as the muficians were now very frequently men of letters, chiefly monks, or fober characters and decent manners, mufic again became a refpectable ftudy. The organift was generally a man of fcience, as well as a performer. At the firft revival of learning in Europe, we find mufic ftudied and honoured with degrees in the univerfities, and very foon we have learned and excellent differtations on the principles of the fcience. The inventions of Guido, and the differtations of Salinas, Zarlino, and Zoni, are among the moft valuable publications that are extant on mufic. The imporvements introduced by Guido are founded on a very refined examina- 36

(c) It is faid that the Chinefe had an inftrument of this kind long before the Europeans. Caufeus fays, that it was brought from China by a native, and was fo fmall as to be carried in the hand. It is certain that the Emperor Conftantine Copronymus fent one to Pepin king of France in 757, and that his fon Charlemagne got another from the Emperor Michael Paleologus. But they appear to have been known in the Englifh churches before that time.

Temperament of the Scale of Music.

examination of the fcale; and the temperaments propofed by the other two have fcarcely been improved by any labours of modern date. Both thefe authors had ftudied the Greek writers with great care, and their improvements proceed on a complete knowledge of the doctrines of Pythagoras and Ptolemy.

37 Galileo difcovered that mufical pitch confifted in the frequency of the aëreal undulations.

At laft the celebrated Galileo Galilei put the finifhing hand to the doctrines of thofe ancient philofophers, by the difcovery of the connection which fubfifts in nature between the ratios of numbers and the mufical intervals of founds. He difcovered, that thefe numbers exprefs the frequency of the recurring pulfes or undulations of air which excite in us the fenfation of found. He demonftrated that if two ftrings, of the fame matter and thicknefs, be ftretched by equal weights, and be twanged or pinched fo as to vibrate, the times of their vibrations will be as their lengths, and the frequency or number of ofcillations made in a given time will be inverfely as their lengths. The frequency of the fonorous undulations of the air is therefore inverfely as the length of the ftring. When therefore we fay that 2 : 1 is the ratio of the octave, we mean, that the undulations which produce the upper found of this interval are twice as frequent as thofe which produce its fundamental found. And the ratio 3 : 2 of the diapente or fifth, indicates, that in the fame time that the ear receives three undulations from the upper found, it receives only two from the lower. Here we have a natural connection, not peculiar to the founds produced by ftrings; for we are now able to demonftrate, that the founds produced by bells are regulated by the fame law. Nay, the improvements which have been made in the fcience of motion fince the days of Galileo, fhew us that the undulations of the air in pipes, where the air is the *only* fubftance moved, is regulated by the fame law. It feems to be the general property of founds which renders them fufceptible of mufical pitch, of acutenefs, or gravity; and that a certain frequency of the fonorous undulations gives a determined and unalterable mufical note. The writer of this article has verified this by many experiments. He finds, that *any noife whatever*, if repeated 240 times in a fecond, at equal intervals, produces the note C *fol fa ut* of the Gindonian gamut. If it be repeated 360 times, it produces the G *fol re ut*, &c. It was imagined, that only certain regular agitations of the air, fuch as are produced by the tremor or vibration of elaftic bodies, are fitted for exciting in us the fenfation of a mufical note. But he found, by the moft diftinct experiments, that any noife whatever will have the fame effect, if repeated with due frequency, not lefs than 30 or 40 times in a fecond. Nothing furely can have lefs pretenfion to the name of a mufical found than the folitary fnap which a quill makes when drawn from one tooth of a comb to another: but when the quill is held to the teeth of a wheel, whirling at fuch a rate, that 720 teeth pafs under it in a fecond, the found of *g in alt.* is heard moft diftinctly; and if the rate of the wheel's motion be varied in any proportion, the noife made by the quill is mixed in the moft diftinct manner with the mufical note correfponding to the frequency of the fnaps. The *kind* of the original noife determines the kind of the continuous found produced by it, making it harfh and fretful, or fmooth and mellow, according as the original noife is abrupt or gradual: but even the moft abrupt noife produces a tolerably fmooth found when fufficiently frequent. Nothing can be more abrupt than the fnap juft now mentioned; yet the *g* produced by it has the fmoothnefs of a bird's chirrup. An experiment was made, which was lefs promifing of a found than any that can be thought of. A ftop-cock was fo conftructed, that it opened and fhut the paffage through a pipe 720 times in a fecond. This apparatus was fitted to the pipe of a conduit leading from the bellows to the wind-cheft of an organ. The air was fimply allowed to pafs gently along this pipe by the opening of the cock. When this was repeated 720 times in a fecond, the found *g in alt.* was moft fmoothly uttered, equal in fweetnefs to a clear female voice. When the frequency was reduced to 360, the found was that of a clear but rather harfh man's voice. The cock was now altered in fuch a manner, that it never fhut the hole entirely, but left about one third of it open. When this was repeated 720 times in a fecond, the found was uncommonly fmooth and fweet. When reduced to 360, the found was more mellow than any man's voice at the fame pitch. Various changes were made in the form of the cock, with the intention of rendering the primitive noife more analogous to that produced by a vibrating ftring. Sounds were produced which were pleafant in the extreme. The intelligent reader will fee here an opening made to great additions to practical mufic, and the means of producing mufical founds, of which we have at prefent fcarcely any conception; and this manner of producing them is attended with the peculiar advantage, that an inftrument fo conftructed can never go out of tune in the fmalleft degree. But of this enough at prefent.

38 This frequency is expreffed by the mufical ratios of Pythagoras.

This difcovery of Galileo's completed the Pythagorean theories, by fupplying the only thing wanted for procuring confidence in them. We now fee that the mufic of founds depends on principles as certain and as plain as the elements of Euclid, and that every thing relating to the fcale of mufic is attainable by mathematics. It is very true that we do not perceive the ratio 3 : 2 in the diapente, as having any relation to the numbers 3 and 2. But we perceive the fweetnefs of found which characterifes this concord. This is undoubtedly the perception of a certain phyfical fact involving this ratio, as much as the fweetnefs on our tongue is the perception of a certain manner of acting of the particles of fugar during their diffolution in the faliva.

Concord, Discord, are properties of particular ratios of frequency.

The pleafure arifing from certain confonances, fuch as *do fol*, is not more diftinctly perceived than is the difagreeable feeling which other confonances produce, fuch as *do re*; and it was a fair field of difquifition to difcover why the one pleafed and the other difpleafed. We cannot fay that this queftion has been completely decided. It has been afcribed to the coincidence of vibrations. In the octave, every fecond vibration of the treble note may be made to coincide with every vibration of the bafs. But the pleafure arifing from the different confonances does by no means follow the proportions of thofe coincidences of vibrations; for when two notes are infinitely near to the ftate which would produce a complete coincidence, the actual coincidence is then exceedingly rare; and yet we know that fuch founds yield very fine harmony. In tuning any concord, when the two notes are very difcordant, the coinciding vibrations recur very frequently; and as we approach

Tempera-ment of the Scale of Mufic.

proach nearer and nearer to perfect concord, thefe coincidences become rarer and rarer; and if it be infinitely near to perfect concord, the coincidences of vibration will be infinitely diftant from each other. This, and many other irrefragable arguments, demonftrate that coalefcence of found, which makes the pleafing harmony of a fifth, for example, does not arife from the coincidence of vibrations; and the only thing which we can demonftrate to obtain in all the cafes where we enjoy this pleafure, is a certain arrangement of the component pulfes, and a certain law of fucceffion of the diflocations or intervals between the non-coinciding pulfes. We are perfectly able to demonftrate that when, by continually fcrewing up one of the notes of a confonance, we render the real coincidence of pulfes lefs frequent; the diflocations, or deviations from perfect coincidence, approach nearer and nearer to a certain defineable law of fucceffion; and that this law obtains completely, when the perfect ratio of the duration of the pulfe is attained, although perhaps at that time not one pulfe of the one found coincides with a pulfe of the other. Suppofe two organ pipes, founding the note C *fol fa ut*, at the diftance of ten feet from each other, and that their pulfes begin and end at the fame inftant, making the moft perfect coincidence of pulfes—there is no doubt but that there will be the moft perfect harmony; and we learn by experience that this harmony is perfectly the fame, from whatever part of the room we hear it. This is an unqueftionable fact. A perfon fituated exactly in the middle between them will receive coincident pulfes. But let him approach one foot nearer to one of the pipes, it is now demonftrable that the pulfes, at their arrival at his ear, will be the moft diftant from coincidence that is poffible; for every pulfe of one pipe will bifect the pulfe from the other: but the law of fucceffion of the deviations from coincidence will then obtain in the moft perfect manner. A mufical found is the fenfation of a certain form of the aerial undulation which agitates the auditory organ. The perception of harmonious found is the fenfation produced by another definite form of the agitation. This is the compofition of two other agitations; but it is the compound agitation only that affects the ear, and it is its form or kind which determines the fenfation, making it pleafant or unpleafant.

39 [...]nce a-[...]s the [...]at ufe of [...]thema-[...] in mu-[...]

Our knowledge of mechanics enables us to defcribe this form, and every circumftance in which one agitation can differ from another, and to difcover general features or circumftances of refemblance, which, in fact, accompany all perceptions of harmony. We are furely intitled to fay that thefe circumftances are fure tefts of harmony; and that when we have enfured their prefence, we have enfured the hearing of harmony in the adjufted founds. We can even go farther in fome cafes: We can explain fome appearances which accompany imperfect harmony, and perceive the connection between certain diftinct refults of imperfect coincidences, and the magnitude of the deviations from perfect harmony which are then heard. Thus, we can make ufe of thefe phenomena, in order to afcertain and meafure thofe deviations; and if any rules of temperament fhould require a certain determinate deviation from perfect harmony in the tuning of an inftrument, we can fecure the appearance of that phenomenon which correfponds to the deviation, and thus can produce the precife temperament fuggefted by our rules. We can, for example, deftroy the perfect harmony of the fifth C *g*, and flatten the note *g* till it deviates from a perfect fifth in the exact ratio of 320 to 321, which the muficians call the one-fourth of a comma. The moft exquifite ear for melody is almoft infenfible of a deviation four times greater than this; and yet a perfon who has no mufical ear at all, can execute this temperament by the rules of harmony without the error of the fortieth part of a comma.

40 Beatings of imperfect confonances.

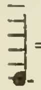
For this moft valuable piece of knowledge we are indebted to the late Dr Robert Smith of Cambridge, a very eminent geometer and philofopher, and a good judge of mufic, and very pleafing performer on the organ and harpfichord. This gentleman, in his Differtation on the Principles of Harmonics, publifhed for the firft time in 1749, has paid particular attention to a phenomenon in coexiftent founds, called a *beating*. This is an alternate enforcement and diminution of the ftrength of found, fomething like what is called a clofe fhake, but differing from it in having no variation in the pitch of the founds. It is a fort of undulation of the found, in which it becomes alternately louder and fainter. It may be often perceived in the found of bells and mufical glaffes, and alfo in the founds of particular ftrings. It is produced in this way: Suppofe two unifons quite perfect; the vibrations of each are either perfectly coincident, or each pulfe of one found is interpofed in the fame fituation between each pulfe of the other. In either cafe they fucceed each other with fuch rapidity, that we cannot perceive them, and the whole appears an uniform found. But fuppofe that one of the founds has 240 pulfes in a fecond, which is the undulation that is produced in a pipe of 24 inches long; fuppofe that the other pipe is only 23 inches and $\frac{7}{10}$ths long. It will give 243 pulfes in a fecond. Therefore the 1ft, the 80th, the 160th, and the 240th pulfe of the firft pipe will coincide with the 1ft, the 81ft, the 162d, and the 243d pulfe of the other. In the incidents of coincidence, the agitation produced by one pulfe is increafed by that produced by the other. The commencement of the next two pulfes is feparated a little, and that of the next is feparated ftill more, and fo on continually: the *diflocations* of the pulfes, or their deviations from perfect coincidence, continually increafing, till we come to the 40th pulfe of the one pipe, which will commence in the middle of the 41ft pulfe of the other pipe; and the pulfes will now bifect each other, fo that the agitations of the one will counteract or weaken thofe of the other. Thus the compounded found will be ftronger at the coincidences of the pulfes, and fainter when they bifect each other. This reinforcement of found will therefore recur thrice in every fecond. The frequency of the pulfes are in the ratio of a comma, or 81 : 80. Therefore this conftitutes an *unifon imperfect by a comma*. If therefore any circumftance fhould require that thefe two pulfes fhould form an unifon imperfect by a comma, we have only to alter one of the pipes, till the two, when founded together, beat thrice in a fecond. Nothing can be plainer than this Now let us fuppofe a third pipe tuned an exact fifth to the firft of thefe two. There will be no beating obfervable; becaufe the recurrence of coincident pulfes is fo rapid as to appear a continued found. They recur at every fecond vibration of the bafs, or 120 times in a fecond.

But

But now, inſtead of ſounding the third pipe along with the firſt, let it ſound along with the ſecond. Dr Smith demonſtrates, that they will beat in the ſame manner as the uniſons did, but thrice as often, or nine times in a ſecond. When therefore the fifth C *g* beats nine times in a ſecond, we know that it is too ſharp or too flat (very nearly) by a comma.

41
Dr Smith applies them to the ſcience and practice of muſic with great effect.

Dr Smith ſhews, in like manner, what number of beats are made in any given time by any concord, imperfect or tempered, in any aſſigned degree. We humbly think that the moſt inattentive perſon muſt be ſenſible of the very great value of this diſcovery. We are obliged to call it *his* diſcovery. Merſennus, indeed, had taken particular notice of this undulation of imperfect conſonances, and had offered conjectures as to their cauſe; conjectures not unworthy of his great ingenuity. Mr Sauveur alſo takes a ſtill more particular notice of this phenomenon *, and makes a moſt ingenious uſe of it for the ſolution of a very important muſical problem; namely, to determine the preciſe number of pulſes which produce any given note of the gamut. His method is indeed operoſe and delicate, even as ſimplified and improved by Dr Smith. The following may be ſubſtituted for it, founded on the mechaniſm of ſounding chords. Let a violin, guitar, or any ſuch inſtrument, be fixed up againſt a wall, with the finger-board downward, and in ſuch a manner, that a violin ſtring, ſtrained by a weight, may preſs on the bridge, but hang free of the lower end of the finger-board. Let another ſtring be ſtrained by one of the tuning pins till it be in uniſon with ſome note (ſuppoſe C) of the harpſichord. Then hang weights on the other ſtrings, till, upon drawing the bow acroſs both ſtrings, at a ſmall diſtance below the bridge, they are perfect uniſons, without the ſmalleſt beating or undulation, and taking care that the preſſure of the bow on that ſtring which is tuned by the pin be ſo moderate as not to affect its tenſion ſenſibly. Note exactly the weight that is now appended to it. Now increaſe this weight in the proportion of the ſquare of 80 to the ſquare of 81; that is, add to it its 40th part very nearly. Now draw the bow again acroſs the ſtrings with the ſame caution as before. The ſounds will now beat remarkably; for the vibrations of the loaded ſtring are now accelerated in the proportion of 80 to 81. Count the number of undulations made in ſome ſmall number (ſuppoſe 10) of ſeconds. This will give the number of beats in a ſecond; 80 times this number are the ſingle pulſes of the loweſt ſound; and 81 times the ſame number gives the pulſes of the higheſt of theſe imperfect uniſons.

Pulſes of  = 140.

* *Mem. Acad. Par.* 1701, 1701, 1707, and 1713.

If this experiment be tried for the C in the middle of our harpſichords, it will be found to contain 240 pulſes very nearly; for the ſtrings will beat thrice in a ſecond. The beats are beſt counted by means of a little ball hung to a thread, and made to keep time with the beats.

42
They afford exact meaſures of the temperament of concords,

Here, then, is a phenomenon of the moſt eaſy obſervation, and requiring no ſkill in muſic, by which the pitch of any ſound, and the imperfection of any concord, may be diſcovered with the utmoſt preciſion; and by this method may concordant ſounds be produced, which are abſolutely perfect in their harmony, or having any degree of imperfection or temperament that we pleaſe. An inſtrument may generally be tuned to perfect harmony, in ſome of its notes, without any difficulty, as we ſee done by every blind Crouder. But if a certain determinate degree of imperfection, different perhaps in the different concords, be neceſſary for the proper performance of muſical compoſitions on inſtruments of fixed ſounds, ſuch as thoſe of the organ or harpſichord kind, we do not ſee how it can be diſputed that Dr Smith's theory of the beating of imperfect conſonances is one of the moſt important diſcoveries, both for the practice and the ſcience of muſic, that have been offered to the public. We are inclined to conſider it as the moſt important that has been made ſince the days of Galileo. The only rivals are Dr Brook Taylor's mechanical demonſtration of the vibrations of an elaſtic cord, and its companion, and of the undulations of the air in an organ pipe, and the beautiful inveſtigations of Daniel Bernoulli of the harmonic ſounds which frequently accompany the fundamental note. The muſical theory of Rameau we conſider as a mere whim, not founded in any natural law; and the theory of the grave harmonics by Tartini or Romieu is included in Dr Smith's theory of the beating of imperfect conſonances. This theory enables us to execute any harmonic ſyſtem of temperament with preciſion, and certainty, and eaſe, and to decide on its merit when done.

We are therefore ſurpriſed to ſee this work of Dr Smith greatly undervalued, by a moſt ingenious gentleman in the Philoſophical Tranſactions for 1800, and called a large and obſcure volume, which leaves the matter juſt as it was, and its reſults uſeleſs and impracticable. We are ſorry to ſee this; becauſe we have great expectations from the future labours of this gentleman in the field of harmonics, and his late work is rich in refined and valuable matter. We preſume humbly to recommend to him attention to his own admonitions to a very young and ingenious gentleman, who, he thinks, proceeded too far in animadverting on the writings of Newton, Barrow, and other eminent mathematicians. We alſo beg his leave to obſerve, that Dr Smith's application of his theory may be very erroneous (we do not ſay that it is perfect), in conſequence of his notion of the proportional effects produced on the general harmony by equal temperaments of the different concords. But the theory is untouched by this improper uſe, and ſtands as firmly as any propoſition in Euclid's Elements. We are bound to add to theſe remarks, that we have oftener than once heard muſic performed on the harpſichord deſcribed in the ſecond edition of Dr Smith's Harmonics, both before it was ſent home by the maker (the firſt in his profeſſion), and afterwards by the author himſelf, who was a very pleaſing performer, and we thought its harmony the fineſt we ever heard. Mr Watt, the celebrated engineer, and not leſs eminent philoſopher, built a handſome organ for a public ſociety, and, without the leaſt ear or reliſh for muſic, tuned three octaves of the open diapaſon by one of Dr Smith's tables of beats, with the help of a variable pendulum. Signior Doria, leader of the Edinburgh concert, tried it in preſence of the writer of this article, and ſaid, "Belliſſima—ſopra modo belliſſima!" Signior Doria attempted to ſing along with it, but would not continue, declaring it impoſſible, becauſe the organ was ill-tuned. The truth was, that, on the major key of E^b, the tuning was exceedingly different from what ſhe was accuſtomed to, and ſhe would not try another key. We mention this particular, to ſhew how accurately

rately Mr Watt had been able to execute the temperament he intended.

43 And accurate methods of temperament.

This theory is valuable, therefore, by giving us the management of a phenomenon intimately connected with harmony, and affording us precise and practicable measures of all deviations from it. It bids fair, for this reason, to give us a method of executing any system of temperament which we may find reason to prefer. But we have another ground of estimation of this theory. By its assistance, we are able to ascertain with certainty and precision the true untempered scale of music, which eluded all the attempts of the ingenious Greeks; and we determine it in a way suited to the favourite music of modern times, of which almost all the excellencies and pleasures are derived from harmony. We do not say that this *total* innovation in the principle of musical pleasure is unexceptionable; we rather think it very defective, believing that the thrilling pleasures of music depend more upon the melody or air. We appeal even to instructed musicians, whether the heart and affections are not more affected *(and with much more distinct variety of emotion)* by a fine melody, supported, but not observed, by harmonics judiciously chosen? It appears to us that the effect of harmony, always filled up, is more uniformly the same, and less touching to the soul, than some simple air sung or played by a performer of sensibility and powers of utterance. We do not wonder, then, that the ingenious Greeks deduced all their rules from this department of music, nor at their being so satisfied with the pleasures which it yielded, that they were not solicitous of the additional support of harmony. We see that melody has suffered by the change in every country. There is no Scotchman, Irishman, Pole, or Russian, who does not lament that the skill in composing heart-touching airs is degenerated in his respective nation; and all admire the productions of their muse of "the days that are past." They are "pleasant and mournful to the soul."

But we still prefer the harmonical method of forming the scale, on account of its precision and facility: and we prefer the theory of beats, *because it also gives us the most satisfactory scale of melody*; and this, not by repeated corrections and recorrections, but by a direct process. By a table of beats, every note may be fixed at once, and we have no occasion to return to it and try new combinations; for the beatings of the different concords to one bass being once determined, every beating of any one note with any other is also fixed.

44 Fundamental experiment.

We therefore request the reader's patient attention to the experiment which we have now to propose. This experiment is best made with two organ pipes equally voiced, and pitched to the note C in the middle of our harpsichords. Let one of them at least be a stopped pipe, its piston being made extremely accurate, and at the same time easily moved along the pipe. Let the shank of it be divided into 240 equal parts. The advantage of this form of the experiment is, that the sounds can be continued, with perfect uniformity, for any length of time, if the bellows be properly constructed. In default of this apparatus, the experiment may be made with two harpsichord wires in perfect unison, and touched by a wheel rubbed with rosin instead of a bow, in the way the sounds of the vielle or hurdygurdy are produced. This contrivance also will continue the sounds uniformly at pleasure. A scale of 240 parts must be adapted to one string, and numbered from that end of the string where the wheel or bow is applied to it. Great care must be taken that the shifting of the moveable bridge do not alter the strain on the wire. We may even do pretty well with a bow in place of the wheel; but the sound cannot be long held on in any pitch. In describing the phenomena, we shall rather abide by the string, because the numbers of the scale, or length of the sounding part of the wire, correspond, in fact, much more exactly with the sounds. The deviations of the scale of the pipe do not in the least affect the conclusions we mean to draw, but would require to be mentioned in every instance, which would greatly complicate the process.

Having brought the two open strings into perfect unison, so that no beating whatever is observed in the consonance, slide the moveable bridge slowly along the string while the wheel is turning, beginning the motion from the end most remote from the bow. All the notes of the octave, and all kinds of concords and discords, will be heard; each of the concords being preceded and followed by a ruffling beating, and that succeeded by a grating discord. After this general view of the whole, let the particular harmonious stations of the bridge be more carefully examined as follows.

45 Determination of the octave, and character of concord.

I. Shift the moveable bridge to the division 120. If it has been exactly placed, we shall hear a perfect octave without any beating. It is, however, seldom so exactly set, and we generally hear some beating. By gently shifting the bridge to either side, this beating becomes more or less rapid; and when we have found in which direction the bridge must be moved, we can then slide it along till the beating cease entirely, and the sounds coalesce into one sound. We can scarcely hear the treble or octave note as distinguishable from the bass or fundamental afforded by the other string. If the notes are duly proportioned in loudness, we cannot hear the two as distinct sounds, but a note seemingly the same with the fundamental, only more brilliant. (*N. B.* It would be a great improvement of the apparatus to have a micrometer screw for producing those small motions of the bridge.)

Having thus produced a fine octave, we can now perceive that, as we continue to shift the bridge from its proper place, in either direction, the beating becomes more and more rapid, changes to a violent rattling flutter, and then degenerates into a most disagreeable jar. This phenomenon is observed in the deviation of every concord whatever from perfect harmony, and must be carefully kept in remembrance.

46 Harmony is more strict than melody.

Before we quit this concord, the octave, produced by the bisection of the pipe or string, we must observe, that, with respect to ourselves, the octave $c\ \bar{c}$ must beat almost twice in a second, before we can observe clearly any mis-tune in it, by sounding the notes in succession, or as steps in the scale of melody. We never knew any ear so nice as to discover a mis-tuning when it beats but once in three seconds. We think ourselves intitled therefore to say, that we are insensible of a temperament in melody amounting to one-third of a comma; and we never knew a person sensible of a temperament half this bulk.

When the imperfection of the octave is clearly sensible by sounding the notes in succession, it is extremely disagreeable, feeling like a struggle or endeavour to attain

Temperament of the Scale of Music.

tain a certain note, and a failure in the attempt. This seems owing to the familiar similarity of octaves, in the habitual talking and singing of men and women together. But when the notes are sounded together, although we are not much more sensible of the imperfection of the harmony directly, as a failure in the sweetness of the concord, we are very sensible of this phenomenon of beating; and any person who can distinguish a weak sound from a stronger one, can easily perceive, in this indirect manner, any fraction of a comma, however minute. This makes the tuning by harmony much more exact than by melody alone. It is also much more accommodated to the genius of modern music. The ancients had favourite passages, which were frequently introduced into their airs, and they were solicitous to have these in good tune. It appears from passages in the writings of Galen, that different performers excelled chiefly in their skill in making those occasional temperaments which their music required. Our music is much more strict, by reason of our harmonic accompanyments, which are an abominable noise when mis-tuned in a degree, which would have passed with the ancients for very good melody. Aristoxenus says, that the ear cannot discover the error of a comma. This would now be intolerable.

47 It gives the best scale for melody.

But another advantage attends our method. We obtain, by its assistance, the most perfect scale of melody; perfect in a degree attainable only by chance by the Greeks. This is now to be our business to unfold.

48 Determination of the Vth.

II. Set the moveable bridge at 158, and sound the two strings. They will beat very disagreeably, being plainly out of tune. Slide it gradually toward 160, and the beats will grow slower and slower; will change to a gentle and not unpleasant undulation; and at last, when the bridge is at 160, will vanish entirely, and the two sounds will coalesce into one sweet concord, in which neither of the component sounds can be distinguished. If the sound given by the short string be now examined as a step in the scale of melody, it will be found a fifth to the sound of the long string or fundamental note, perfectly satisfactory to the nicest ear. Thus one step of the scale has been ascertained.

III. Slide the bridge slowly along the string. The beating will recommence, will become the flutter, and then a jarring noise; and will again change to an angry flutter, beating about eight times in a second, when the bridge stands at 169 nearly. Pushing it still on, but very slowly, the flutter will become an indistinct jarring noise; which, by continuing the motion, will again become a flutter, or beat about six in the second. The bridge is now about 171.

49 Determination of the 4th.

IV. Still continuing the motion, the flutter becomes a jarring noise, which continues till the bridge is near to 180, when the rapid flutter will again be heard. This will become slower and slower as we approach to 180; and when the bridge reaches that point, all beating vanishes, and we have a soft and agreeable concord, but far inferior to the former concord in that cheering sweetness which characterises the fifth. When this note is compared with that of the fundamental string as a step in the scale of melody, it is found to correspond to the note *fa*, or the fourth step in the scale, and in that employment to give complete satisfaction to the ear.

V. Still advancing the moveable bridge toward the nut, we shall hear the beatings return again; and after fluttering and degenerating to a jarring noise, by a very small motion of the bridge, they will again be heard, will grow slower, accompanied with a sort of angry expression, and will cease entirely when the bridge reaches the 192d division of our scale. Here we have another concord of very peculiar character, being remarkably enlivening and gay. This sound gives perfect satisfaction to the ear, if employed as the third step in the scale of melody, being the note *mi* of that series, at least in all gay or cheerful airs. 50

Determination of the IIId.

VI. As we move the bridge from 192 to 200, we hear again the same beatings, which, in the immediate vicinity to 192, have a peevish fretful expression, instead of the angry waspish expression before mentioned. When the bridge has passed that situation which produces only grating discordance, we hear the beatings again, and they become slower, and cease altogether when the bridge arrives at 200. Here we have another consonance, which must be called a *concord*, because it is rather agreeable than otherwise, but strongly marked by a mournful melancholy in the expression. In the scale of melody, it forms the third step in those airs which express lamentation or grief. It is called the *minor third*, to distinguish it from the last enlivening concord, which, being a larger interval, is called the *major third*. 51

52 Determination of the 3d.

It is well known, that these two thirds give the distinguishing characters to the only two modes of melodious composition that are admitted into modern music. The series containing the major third is called the *major*, and that containing the minor third is called the *minor mode*. It is worthy of remark, that the fanatical preachers, in their conventicles and field sermons, affect this mode in their harangues, which are often distinctly musical, modulating entirely by musical intervals, and keeping the whole of their chaunt in subordination to a fundamental or key note. This is not unnatural, when we consider the general scope of their discourses, namely, to inspire melancholy and humiliating thoughts, awakening sorrow, and the like. It is not so easy to account for the usual whine of a beggar, who generally craves charity in the major third. This is the case, at least, in the northern parts of this island.

If we continue to shift the bridge still nearer to the end of the string, we shall hear nothing but a succession of vile discordant noises, somewhat less offensive when the bridge is about the divisions 213 and 216, but even there are very unpleasant. 53

54 Determination of the 6th.

VII. Let us therefore change our manner of proceeding a little, and again place the bridge at 160, which will give us the pleasing concord of the fifth. Instead of pushing it from that place toward the nut, let it be moved toward the wheel or bow. Without repeating what we have said of the appearance of the beatings, their acceleration, and their degenerating into a jarring discord, to be afterwards succeeded by another beating, &c. &c. we shall only observe, that when we place the bridge at 150, we have no beatings, and we hear a consonance, which is in a slight degree pleasant, and may therefore be called a *concord*. It has the other marks of a concord which we have been making so much use of; for the beatings recommence when we shift the bridge to either side of 150. This note makes the sixth step in the descending scale of mournful melody;

Temperament of the Scale of Muſic.

lody; that is, when we are paſſing from the acute to the graver notes, with the intention of putting an emphaſis on the third and the fundamental. Although not eminent as a concord with the fundamental alone, it has a moſt pleaſing effect when liſtened to in ſubordination to the whole ſeries, or when ſounded along with other proper accompanyments of the fundamental.

55 Determination of the VIth.

VIII Placing the bridge at 144, we obtain another very pleaſing concord, differing in its expreſſion from any of the foregoing. We find it difficult to expreſs its character. It is greatly inferior to the fifth in ſweetneſs, and to the major third in gaiety, but ſeems to poſſeſs, in a lower degree, both of theſe qualities. In the ſcale of cheerful melody, it is the ſixth note, which we have diſtinguiſhed by the ſyllable *la*. It is alſo uſed even in mournful melody, when we are aſcending, with the intention of cloſing with the octave.

56 Scale of the upper octave.

In ſhifting the bridge from 144 to 120, we obtain nothing but diſcordant, or at leaſt diſagreeable conſonances. And, laſtly, if we move the bridge beyond 120, to diviſions which are reſpectively the halves of thoſe numbers which produced the concords already treated of, we obtain the ſame ſteps in the ſcale of the upper octave. Thus if the bridge be at 80, we have the fifth to the octave note, or twelfth to the fundamental. If it be at 60, we obtain the double octave, &c. &c. &c.

57 Characters of the different concords.

We have perhaps been raſh in affixing certain moral or ſentimental characters to certain concords; for we have ſeen inſtances of perſons who gave them different denominations; but theſe were never contradictory to ours, but always expreſſed ſome ſentiment allied to that which we have aſſigned. We never met with an inſtance of a perſon capable of a little diſcriminating reflection, who did not acknowledge a manifeſt ſentimental diſtinction among the different concords which could not be confounded. We doubt not but that the Greeks, a people of exquiſite ſenſibility to all the beauties of taſte and ſentiment, paid much attention to theſe characters, and availed themſelves of them in their compoſitions. We do not think it at all unlikely, that greater effects have been produced by their muſic, which was ſtudied with this expreſs view, than have ever been produced by the modern muſic, with all the addition of harmony. We have allowed too great a ſhare of our attention to mere harmony. Our great authors are much leſs ſolicitous to compoſe an enchanting air, than to conſtruct a full ſcore of rich and well conducted harmony. We do not profeſs to be nice judges in muſical compoſition, but we may tell what we ourſelves experience. We find our minds worked up by a continuance of fine harmony into a *general* ſenſibility; into a frame of mind which would prepare and fit us for receiving ſtrong impreſſions of moral ſentiment, if theſe were diſtinctly made. But we have ſeldom felt any diſtinct emotions excited by mere inſtrumental muſic. And when the harmonies have been merely to ſupport the performance of a voice, the words have been either ſo frittered by muſical diviſions, as to become in ſome meaſure ludicrous—or have been ſo indiſtinct; and made ſo trifling a part of the muſic, that there was nothing done to give a particular ſhape to the moral impreſſion on our mind. We have generally been ſtrongly affected by ſome of the anthems which were in vogue in former times; and we think that we perceived the cauſe of this difference: There was a great ſimplicity in the voice parts: the ſyllables were not drawled out into long muſical phraſes, but pronounced nearly according to their proper quantities; ſo that the ſentiment of the ſpeaker was expreſſed with all the force of good declamation, and the harmony of the accompanyment then ſtrengthened the appropriate effect of the melody. We mean not to offer theſe obſervations as of much authority, but merely to mention ſome facts, and to aſſign what we felt to be their cauſes, in order to promote, in ſome degree, however inſignificant, the cultivation of muſical ſcience. With this view, we venture to ſay, that ſome of the beſt compoſitions of Knapp of York *uniformly* affect us more than the more admired anthems of Bird and Tallis. A cadence, which Knapp gives almoſt entirely to the melody, is laboured by Bird or Tallis with all the rules of art; and you have its characters of perfect or imperfect, full or diſappointed, cadences, and ſuch an apparatus of preparation and reſolution of diſcords, that you foreſee it at the diſtance of ſeveral bars, and then the part aſſigned to the voice ſeems a very trifle, and merely to fill up a blank in the harmony. Such compoſitions ſmell of the lamp, and fail of their purpoſe, that of charming the *learned* ear. But enough of this digreſſion.

58

Thus have we found a natural relation between certain ſounds ſtrongly marked by very preciſe characters. The concordance of ſound is marked by the abſence of all undulation, and the deviations from this harmony are ſhewn to be meaſurable by the frequency of thoſe undulations. We have alſo found, that the notes, which are thus harmonious along with the fundamental, are ſteps in the ſcale of natural muſic (for we muſt acknowledge melody to be the primitive muſic, dictated by nature). We have got the notes—*do*—*mi*, *fa*, *ſol*, *la*—*do*, aſcertained in a way that can no longer be miſtaken.

59 Ratios belonging to the concords, &c.

Let us now examine what phyſical or mechanical relations theſe ſounds ſtand into each other. Our monochord gives us the lengths of the ſtrings; and the diſcovery of Galileo ſhews us, that theſe are alſo the durations of the aërial pulſes which produce the ſenſations of muſical notes. Their ratios may therefore be truly called the ratios of the ſounds. Now we ſee that the ſtrings which produce the ſounds *do ſol* are 240 and 160. Theſe are in the ratio of 3 to 2. In this manner we may ſtate all the ratios obſerved in our experiment, *viz.*

Do : *mi* have the ratio of	240 to 192, or of	5 to 4
Do : *fa*	240 : 180	4 : 3
Do : *ſol*	240 : 160	3 : 2
Do : *la*	240 : 144	5 : 3
Mi : *ſol*	192 : 160	6 : 5, = *do* : *mi*^{b}
Fa : *ſol*	180 : 160	9 : 8
Sol : *la*	160 : 144	10 : 9
Mi : *fa*	192 : 180	16 : 15

Here we get the ſight of all the ratios which the ingenious and unwearied ſpeculations of the Greek mathematicians enliſted into the ſervice of muſic, without being able to give a good reaſon why. The ratio 5 : 4, which their faſtidious metaphyſicians rejected, and which others wiſhed to introduce from motives of mere neceſſity to fill up a blank, is pointed out to us by one of the fineſt concords. The interval between the fourth and fifth is, *very fortunately*, a ſtep of the ſcale.

The

Temperament of the Scale of Music.

The next ſtep *ſol la* is more important. For the ear for melody would have been very well ſatisfied with an interval equal to *fa ſol*, or 9 : 8 ; but if the moveable bridge be ſet at the diviſion $142\frac{2}{9}$, correſponding to ſuch a ſtep, we ſhould have a very offenſive fluttering. It is reaſonable therefore to conclude, *from analogy*, that the interval *ſol la* does not correſpond to the ratio 9 : 8 ; and that 10 : 9, which is, at leaſt, equally ſatisfactory to the ear, is the proper ſtep, even in the ſcale of melody. If we conſider what may be called the ſcale of harmony, there is no room left for doubt. To enjoy the greateſt poſſible pleaſure of harmony, we muſt not only take each note as it is related to the fundamental, but alſo as it is related to other notes of the ſcale. It may chance to be convenient to aſſume for the fundamental of our occaſional ſcale of modulation, the ſtring of the lyre which is tuned as *fa* to its proper fundamental ; or it may increaſe the harmony (and we know that it does), if we accompany the note *do* with both of the notes *fa* and *la*. To have the fine concord of the major third, it is neceſſary that the interval *fa la* be equivalent to the ratio 5 : 4. Now *fa* is 180, and 5 : 4 = 180 : 144. Therefore, by making the ſtep *ſol la* equal to 9 : 8, we ſhould loſe this agreeable concord, and get diſcord in its place.

60 Obſervations on the ſtep *ſol la*.

And thus is evinced, in oppoſition to Ariſtoxenus, the propriety of having both a major and a minor tone ; the firſt expreſſed by 9 : 8, and the laſt by 10 : 9. The difference between theſe ſteps is the ratio 81 : 80, called a comma by the Greek theoriſts.

61 Determination of the VIIth.

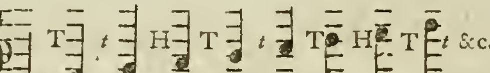
We ſtill want two ſteps of the ſcale, and two ſounds or notes correſponding to them, namely *re* and *ſi* ; and we wiſh to eſtabliſh them on the ſame authority with the reſt. We ſee that this cannot be done by a concordance with the fundamental *do*. The ear ſufficiently informs us that the ſteps *do re* and *la ſi* muſt be tones, and not ſemitones, like *mi fa*. The ſenſible ſimilarity of the two tetrachords, *do re mi fa* and *ſol la ſi do*, alſo teaches us that the ſtep *ſi do* ſhould be a ſemitone like *mi fa*. This ſeems to be all that mere melody can teach us. But we have little information whether we ſhall make *la ſi* a major or a minor tone. If we copy the tetrachord *do re mi fa* exactly, we ſhall make the ſtep *ſi do* like *mi fa*, and equivalent to the ratio 16 : 15. This requires the moveable bridge to be placed at 128. The ſound produced by this diviſion is perfectly ſatisfactory to the ear as a ſtep of the ſcale of melody. Moreover, our ſatisfaction is not confined to the compariſon of it with the note *do*, into which we ſlide by this gentle ſtep. It makes agreeable melody when uſed as the third to the note *ſol*. If we examine it mathematically, we find it a perfect major third to *ſol* ; for *ſol* requires the 160th diviſion. Now 160 : 128 = 5 : 4, which is the ratio of the pulſes of a major third. All theſe reaſons ſeem enough to make us adopt this determination of the note *ſi*.

62 Determination of the IIId.

It remains to conſider how we ſhall divide the interval *do*—*mi*. It is a perfect major third. So is *fa la*, and ſo is *ſol ſi*. But in the firſt of theſe two, we have ſeen that it muſt be compoſed of a major tone with a minor tone above it ; and in the ſecond we have a minor tone followed by a major tone above. We are left uncertain therefore whether *do re* ſhall reſemble *fa la* or *ſol ſi* in the poſition of its two parts. Ariſtoxenus and his followers declared the ear to be equally pleaſed with both. Ptolemy's *Syſtema Diatonicum Intenſum* makes *do re* a major tone, and other ſyſtems make it minor. Even in modern times it has been conſidered as uncertain ; and the only reaſon which we have to offer for a preference of the major tone for the firſt ſtep is, that, ſo far as we can judge by our own feelings, the ſounds in the relation of 9 : 8 are leſs diſcordant than ſounds in the relation of 10 : 9, and becauſe all the other ſteps have been determined by means of concords with the key. We refer, for a more particular examination of the principles on which theſe arrangements are valued, to *Dr Smith's Harmonics*, Prop. I. where he ſhews how one is preferable to another, in proportion as it affords a greater number of perfect concords among the neighbouring notes, which is the favourite object in all modern muſic. Upon this principle our arrangement is by far the beſt, becauſe it admits five more concords in the octave than the other. But we have conſidered the ſubject in a different manner, merely to avail ourſelves of the phenomenon by which all the ſteps, except one, ſeem to be naturally aſcertained, and by which the connection between harmony and melody ſeems to be pointed out to us.

It will be convenient to repreſent the tones major and minor and the hemitone, by the ſymbols T, *t*, and H. Alſo to mark the notes by the Roman numerals, or by cyphers according as they are the extremes of major or minor intervals. By this notation the octave may be repreſented thus: 63

C D E F G A B *c* *d* *c*



$\frac{8}{9}$ $\frac{9}{10}$ $\frac{15}{16}$ $\frac{8}{9}$ $\frac{9}{10}$ $\frac{8}{9}$ $\frac{15}{16}$ $\frac{8}{9}$ &c.

K II III 4 V VI VII VIII IX X &c.

The reader will remark, that the primary diviſions which we aſſigned to the repreſentation of an octave in fig. 1. by the circumference of a circle, are in conformity to this Ptolemaic partition of the octave. He will alſo be ſenſible, that the diviſion into five equal mean tones and two equal hemitones, which is expreſſed by the dotted lines, agreeing with the Ptolemaic diviſion only at C and E, is effected by biſecting the arch CE ; and therefore the deviation of the ſound ſubſtituted for the Ptolemaic D is half the difference of CD and DE, that is, half a comma. The deviations therefore at F, G, A, and B, are each a quarter of a comma.

Logarithmic meaſures of muſical intervals.

It is well known, that if the logarithm of the length of one ſtring be ſubtracted from that of another, the difference is a meaſure of the ratio between them. Therefore 30103 is the meaſure of the muſical interval called the octave, and then the meaſures of the

Comma . .	540 or	54
Hemitone . .	2803	280
Minor tone . .	4576	458
Major tone . .	5115	512
3d . . .	7918	792
IIId . . .	9691	969
4th . . .	12494	1249
Vth . . .	17609	1761
6th . . .	20412	2041
VIth . . .	22185	2219
VIIth . .	27300	2730
VIIIth . .	30103	3010

This is a very convenient circumſtance. If we take only the four firſt figures as integers, and make the octave

Temperament of the Scale of Music.

octave consist of 3010 parts, we have a scale more exact than the nicest harmony requires. The circumference of a circle may be so divided into 301 degrees, and the moveable circle have a nonius, subdividing each into 10 Or it may be divided into 55,8 degrees, each of which will be a comma. Either of these divisions will make it a most convenient instrument for expeditiously examining all temperaments of the scale that can be proposed. Or a straight line may be so divided, and repeated thrice. Then a sliding ruler, divided in the same manner, and applied to it, will answer the same purpose. We shall see many useful employments of these instruments by and by.

64 Having thus endeavoured to communicate some plain notion of the formation and singular nature of that gradation of sounds which produces all the pleasures of music, and of the manner of obtaining the steps of this gradation with certainty and precision, we proceed to consider how those musical passages may be performed on such keyed instruments as the organs and harpsichords, as they are now constructed. These instruments have twelve sounds and intervals in every octave, in order that an air may be performed in any pitch; that is, taking any one of the sounds as a key note. It is plain that this cannot be done with accuracy; for we have now seen that the interval *mi fa* is bigger than half of *do re* or *re mi*, &c. and therefore the intercalary sound formerly mentioned to be inserted between C and D, D and E, &c. will not do indiscriminately for the sharp of the sound below and the flat of the sound above it. When the tones are reduced to a mean size, the ear is scarcely sensible of the change in melody, and the harmony of the fifths and fourths is not greatly hurt. But when the half notes are inserted, and employed to make up harmonious intervals, as recommended by Zarlino, the harmony is very coarse indeed.

65 Why temperament necessary.

But we must make the reader sensible of the necessity of some temperament, even independent of those artificial notes. Therefore

Let the scholar tune upwards the four Vths $c\,g$, $g\,\bar{d}$, $\bar{d}\,\bar{a}$, $\bar{a}\,\bar{\bar{e}}$, all perfect, admitting no beating whatever. This is easily done, either with the organ or the wheel monochord already described. Then tune downwards the perfect octaves $\bar{\bar{e}}\,\bar{e}$, $\bar{e}\,e$. Now examine the IIId $c\,e$ which results from this process. If the instrument be of the pitch hitherto supposed (c making 240 pulses in a second,) this IIId will be heard beating 15 times in a second, which is a discordance altogether intolerable, the note e being too sharp in the ratio of 81 to 80, which makes a comma. It is easily found, by calculation, that e makes $303\frac{3}{4}$ pulses, instead of 300, required for the IIId to c.

N. B. It may not be amiss to inform our readers, that if any concord, whose perfect ratio is $\frac{m}{n}$ (m being the greatest term of the smallest integers expressing that ratio), be tempered sharp by the fraction $\frac{p}{q}$ of a comma, and if M and N be the pulses made by the acute and grave notes of the concord during any number of seconds, the number b of beats made in the same time by this concord will be $= \frac{2\,q\,m\,\mathrm{N}}{161\,p-q}$, or $\frac{2\,q\,n\,\mathrm{M}}{161\,p+q}$; and if it be tempered flat, then $b = \frac{2\,q\,m\,\mathrm{N}}{161\,p+q}$, or $\frac{2\,q\,n\,\mathrm{M}}{161\,p-q}$ (*Smith's Harm.* 2d edit. p. 82, &c.)

65. It is impossible, therefore, to have perfect Vths and perfect IIIds at the same time. And it will be found, that the 3d $e\,g$ resulting from this process, and the VIth $c\,\bar{a}$, are still more discordant, rattling at an intolerable rate. Now the major and minor thirds, alternately succeeding each other, form the greatest part of our harmonies; and the VIth is also a very frequent accompanyment. It is necessary therefore to sacrifice somewhat of the perfect harmony of the Vths, in order that we may not be disgusted with the discord of those other harmonies: and it is this mutual accommodation, and not the changes made necessary by the introduction of intercalary notes, which is properly called TEMPERAMENT. It will greatly assist us in understanding the effects of the temperaments of the different concords, if we examine all the divisions of the circular representation of the octave and musical scale given in fig. 1. by placing the index of the moveable circle on that note of the outer circle for which we want the proper harmonies, or accompanyments, which are either the IIId and Vth, or the 4th and VIth. We shall thus learn, in the *first* place, the deviations of the different perfect notes of the scale from the notes required for this new fundamental; and we must then study what effect the same temperament produces on the agreeableness of the harmony of different concords having the same bass or the same treble, taking it for granted that the hurt to the harmony of any individual concord is proportional to its temperament.

67 How this may be obtained by the beats.

It is in this delicate department of musical science that we think the great merit of Dr Smith's work consists. We see that the deviation from perfect harmony is always accompanied with beats, and increases when they increase in frequency—whether it increases in the same proportion may be a question. We think that Dr Smith's determination of the equality of imperfect harmony in his 13th proposition, includes every mathematical or physical circumstance that appears to have any concern in it. What relates immediately to our sensations is, as yet, an impenetrable secret. The theory of beats, as delivered by this author, affords very easy, though sometimes tedious, methods of measuring and of ensuring all the varieties which can obtain in the beating of imperfect consonances. It appears to us therefore very unjust to say, with the late writer in the Philosophical Transactions, that this obscure volume has left the matter where it found it. The author has given us *effective* principles, although he may have been mistaken in the application; which however we are far from affirming. Our limits will not allow us to give any account of that theory; and indeed our chief aim in the present article is to give a method of temperament which requires no scientific knowledge of the subject. But we could not think of losing the opportunity of communicating, by the way, to unlearned persons, some more distinct notions of the scale of musical sounds, and of its foundation in nature, than scholars usually receive from the greater number of mere music masters. The acknowledged connection of the musical ratios with the pleasures of harmony

Temperament of the Scale of Muſic.

harmony and melody, has (we hope) been employed in an eaſy and not obſcure manner; and the phenomena which we have faithfully narrated, ſhew plainly that, by diminiſhing the rattling undulations of tempered concords, we are certain of improving the harmony of our inſtruments. We ſhall proceed therefore on this principle for the uſe of the mere performer, but at the ſame time introducing ſome very ſimple deductions from Smith's theory, for which we expect the thanks of all ſuch readers as wiſh to ſee a little of the reaſons on which they are to proceed.

68 Method in practice.

The experiment, of which we have juſt now given an account, ſhews that four conſecutive fifths compoſe a greater interval than two octaves and a major third. Yet, in the conſtruction of our muſical inſtruments of fixed ſounds, they muſt be conſidered as of equal extent; ſince we have 7 half intervals in the Vth, and 12 in the octave, and four in the IIId, four Vths contain 28, and two octaves contain 24; and theſe, with the four which compoſe a IIId, make alſo 28. It is plain, therefore, that whatever we do with the IIIds, we muſt leſſen the Vths. If therefore we keep the IIId perfect, we muſt leſſen each of the Vths by $\frac{1}{4}$th of a comma; for we learned, by the beating of the imperfect IIId $c\,e$, that the whole exceſs of the four Vths was a comma. Therefore the Vth $c\,g$ muſt be flattened $\frac{1}{4}$th of a comma. But how is this to be done with accuracy? Recollect the formula given a little ago, where the number of beats b in any number of ſeconds is $= \frac{2\,q\,m\,N}{161 \times p = q}$. In the preſent caſe $q = 1$, $m = 3$, $N = 240$ per ſecond, and $p = 4$. Therefore the formula is $= \frac{2 \times 3 \times 240}{161 \times 4 + 1} = \frac{1440}{645} = 2{,}25$ in a ſecond, or 9 beats in four ſeconds very nearly.

In like manner, the next Vth $g\,\bar{d}$ muſt be flattened $\frac{1}{4}$th of a comma, by making it beat half as faſt again, or $13\frac{1}{2}$ beats in four ſeconds (becauſe in this Vth $N = 360$. But as this beating is rather too quick to be eaſily counted, it will be better to tune downwards the perfect octave g G, which will reduce N to 180 for the Vth G d. This will give us 1,68 per ſecond, or 10 beats in 6 ſeconds very nearly.

There is another way of avoiding the employment of too quick beats. Inſtead of tuning the octave g G, make c G beat as often as $c\,g$. This is even more exactly an octave to g than can be eſtimated by a good ear. Dr Smith has demonſtrated, that when a note makes a minor concord with another note below it, and therefore a major concord with the octave to that note, it beats equally with both; but if the major concord be below, it beats twice as faſt with the octave above. Now in the preſent caſe, $c\,g$ is a Vth, and c G a 4th. For the ſame reaſon $c\,f$ would beat twice as faſt as c F.

In the next place, the Vth $d\,\bar{a}$ muſt be made to beat flat 15 times in 6 ſeconds.

In like manner, inſtead of tuning upward the Vth $\bar{a}\,\bar{\bar{e}}$, tune downward the octave $\bar{a}\,a$, and then tune upward the Vth $a\,e$, and flatten it till it beat 15 times in 8 ſeconds.

If we take 15 ſeconds for the common period of all theſe beats, we ſhall have

Temperament of the Scale of Muſic.

The beats of $c\,g = 34$.
G $d = 25$.
$d\,\bar{a} = 37\frac{1}{2}$.
$a\,e = 28$.

69

We ſhall now find $c\,e$ to be a fine IIId, without any ſenſible beating; and then we proceed in the ſame way, always tuning upward a perfect Vth; and when this would lead us too high, and therefore produce too quick beating, we ſhould tune downward an octave. Do this till we reach b ✻, which ſhould be the ſame with $\bar{c}$, or a perfect octave above c. This will be a full proof of our accurate performance. But the beſt proceſs of tuning is to ſtop when we get to g ✻. Then we tune Vths downward from c, and octaves upward when the Vths would lead us too low. Thus we get c F, F f, $f\,b^b$, $b^b\,\bar{b^b}$, $\bar{b^b}\,e^b$, and thus complete the tuning of an octave. We take this method, inſtead of proceeding upwards to $\bar{b}$ ✻; becauſe thoſe notes marked ſharp or flat are, when tuned in this way, in the beſt relation to thoſe with which they are moſt frequently uſed as IIIds.

70 Uſe of a variable pendulum.

This proceſs of temperament will be greatly expedited by employing a little pendulum, made of a ball of about two ounces weight, ſliding on a light deal rod, having at one end a pin hole through it. To prepare this rod, hang it upon a pin ſtuck into the wainſcoating, and ſlide the ball downward, till it makes 20 vibrations in 15″, by comparing it with a houſe clock. In this condition mark the rod at the upper edge of the ball. In like manner, adjuſt it for 24, 28, 32, 36, 40, 44, 48, vibrations, making marks for each, and dividing the ſpaces between them by the eye, noticing their gradual diminution. Then, having calculated the beats of the different Vths, ſet the ball at the mark ſuited to the particular concord, and temper the ſound till the beats keep pace exactly with the pendulum.

71 Abſolute number of pulſes how known.

But previous to all this, we muſt know the number of pulſes made in a ſecond by the C of our inſtrument. For this purpoſe we muſt learn the pulſes of our tuning fork. To learn this, a harpſichord wire muſt be ſtretched by a weight till it be uniſon or octave below our fork: then, by adding $\frac{1}{40}$th of the weight to what is now appended, it will be tempered by a comma, and will beat, when it is ſounded along with the fork; and we muſt multiply the beats by 80: The product is the number of pulſes required. And hence we calculate the pulſes of the C of our inſtrument when it is tuned in perfect concord with the fork.

The uſual concert pitch and the tuning forks are ſo nearly conſonant to 240 pulſes for C, that this proceſs is ſcarcely neceſſary, a quarter of a tone never occaſioning the change of an entire beat in any of our numbers.

72 Syſtem of temperament with perfect IIIds.

The intelligent reader cannot but obſerve, that this ſyſtem of tuning with perfect IIIds, which is preferred to all others by many great maſters, is the one repreſented by our circular figure of the octave. The IIId is there perfect, and the Vth CG is deficient by a quarter of a comma. We cannot here omit taking notice of a moſt valuable obſervation of Dr Smith's on this temperament, and, in general, on any diviſion of the octave into mean tones and equal limmas.

73 Proportional variations of temperament.

The octave being made up of five mean tones and two limmas, it is plain that, by enlarging the tones, we diminiſh the limmas, and that the increment of the tone is two-fifths of the contemporaneous diminution of the

Temperament of the Scale of Music.

the limma. If, therefore, we employ the symbol v to express any minute variation of this temperament, and make the increment of a mean tone $= 2v$, the contemporaneous variation which this induces on a limma will be $= -5v$; and if the tone be diminished by the same quantity $-2v$, the limma will increase by the quantity $5v$. Let us see what are the contemporaneous changes made on all the intervals of the octave when the tone is diminished by $2v$.

1. A Vth is made up of three tones and a limma. Therefore the variation of its temperament is $= -6v + 5v$, or is $= -v$. That is, the Vth is flattened from its former temperament, whatever that may have been, by the quantity $-v$. Consequently the 4th, which is always the complement of the Vth to the octave, has its temperament sharpened by the quantity v.

2. A IId, being a tone distant from the fundamental, has its temperament changed by $-2v$.

Therefore a minor 7th is raised by $2v$.

3. A minor 3d is made up of a tone and a limma: therefore its variation is $= -2v + 5v$. or $= 3v$.

Therefore a major VIth (its complement) loses $-3v$.

4. A maj. IIId, or two tones, has its variation $= -4v$.

Therefore a minor 6th has its variation $= 4v$.

5. A maj. VIIth, the complement of a limma has $-5v$.

6. A tritone, or IVth, must have the variation $= -6v$.

Therefore the false 5th must have - - - $6v$.

74 Geometrical construction founded on this.

From this observation, Dr Smith deduces the following simple mathematical construction: In the strait line CE (fig. 2.) take the six equal parts Cg, g d, d a, a E, E b, b t, and draw through the points of division the six parallel lines g G, d D, &c. Let these lines represent so many scales of the octave, so placed that the points C, g, d, &c. may represent the points C, g, d, &c. of the circular scale in fig. 1 where it is cut by the dotted lines representing the system of mean tones and limmas. Then, *1st*, take a certain length d G on the first line, to the right hand of the line CE, to represent a quarter of a comma. G will mark the place of the perfect Vth, while g represents that of the mean or tempered Vth. *2dly*, Set off d D, double of g G, in like manner, to the right hand on the second parallel. This will be the place of the perfect IId to the key note C. *3dly*, Also set off a A, on the third parallel, to the left hand, equal to g G. This will mark the place of A, the VIth to the key note C. *4thly*, Place E on the point e, because, in the system of mean tones represented in fig. 1. the IIIds were kept perfect. *5thly*, Make b B, to the right hand on the 5th line, equal to g G, to mark the place of the perfect VIIth to the key note C. And, *6thly*, make t T, to the right hand on the sixth line, equal to twice g G. This will serve for shewing the contemporaneous temperament of the tritone, or IVth, contained between F and B, as also of its complement, the false 5th in fig. 1.

It is evident that the temperament of all the notes of the octave, according to the above mentioned system, are properly represented in this figure. The Vth is tempered flat by the quarter comma G g; the IId is tempered flat by the half comma D d; the VIth is tempered sharp by a quarter comma A a; the IIId is perfect; the VIIth is flat by a quarter comma B b; and the 4th is sharp by a quarter comma G g.

75 The Temperer.

Now, let any other straight line C t' be drawn from C across these parallels. This will mark, by the intervals g' G, d D, &c. the temperaments of another system of mean tones and limmas. For it is evident, that the contemporaneous variations g g', d d', &c. from the former temperament, are in the just proportions to each other; g g' being $= -v$, the variation proper for the Vth, and the opposite temperament for its complement or 4th. In like manner, a a' is $= 3v$, the variation competent to the VIth; and E e' is $= 4v$, the proper variation for the IIId.

In like manner, b b' is $= 5v$, the variation of the VIIth and 2d. And, lastly, t t' is the variation $6v$ of the tritone, and its complement, the false fifth.

For all these reasons, any straight line C e' or C e'', drawn from C across the parallels, may justly be called the TEMPERER.

This is a very useful construction: For it is plain, 76
that the sounds which can be placed in our organs and harpsichords, which have only twelve keys for an octave, must approach to a system of mean tones. The division of the octave into twelve equal intervals is such a system of mean tones exactly. Now, in such systems, when a line is drawn from C across the parallels, we see, at one glance, not only all the temperaments of the notes with the key note, but also the temperaments of those concords which the notes employed in full harmony make with each other. Thus, in the harmony of K — III — V, the III and V make a minor 3d with each other; and in the harmony of K — 4 — VI, the 4 and VI make a major 3d with each other. Now the reader will easily see, that the first of these concords has its interval diminished on both sides, when the IIId is tempered sharp, but only on one side when it is tempered flat. The mathematical reader will also easily see, that the contemporaneous temperament A a' of the VIth is always equal to the sum g' G and E e', and that A a'' is equal to the difference of g'' G and E e''. Therefore the temperament of this subordinate concord, in the full harmony K — III — V, is, in all cases, the same with the contemporaneous temperament of the VIth.

In like manner, he will perceive that the temperament of the subordinate IIId, in the harmony of K — 4 — VI, is equal to the contemporaneous temperament of the III

We also see, in general, that the whole harmony is more hurt when the temperer lies in the angle ECK, with the IIId tempered sharp, than when it is in the angle ACE, when the IIId is flat; and that the sum of all the temperaments of the concords with the key is the smallest when the IIIds are perfect. This system of mean tones, with perfect IIIds, would therefore be the best, if the harmony of different concords were equally hurt by the same temperament.

77 Certain scales of great use.

We do not know any thing that has been published on the science of music that gives more general and speedy instruction than this simple figure. If it be drawn of such a size as to allow the comma EK to be divided into a number of equal parts, sufficiently sensible, all trouble of calculation will be saved.

We would therefore propose to accompany this figure with proper scales.

The *first* scale should have G g divided into $13\frac{1}{2}$ parts. This will express the logarithmic measures of the temperaments mentioned in n° 63. a comma being $= 54$.

The *second* scale should have g G divided into 36 parts.

 This

Temperament of the Scale of Music.

This gives the beats made in 16 feconds by the notes c, g, when tempered by any quantity $G\,g'$.

The *third* fcale fhould have g G divided into 60 parts, for the beats made by the notes c, e, or the notes c, $\bar{a}$.

The *fourth* fcale fhould have g G divided into 72 parts. This gives the beats made by the key note C, with its minor third e^b,

The *fifth* fcale fhould have g G divided into 48 parts, for the beats made by the notes c, f.

The *fixth* fcale fhould have g G divided into 89 parts, on which A a' is meafured, to get the beats of the fubordinate concord formed by g and e in the harmony of K — III — V.

And, *laftly*, g G, divided into 80 parts, will give the beats made by f and $\bar{a}$ in the harmony of K — 4 — VI.

78 Harmonioufnefs, what?

We are ignorant of the immediate efficient caufes of the pleafure we receive from certain confonances, and fhould therefore receive, with fatisfaction, any thing that can help us to approximate to a meafure of its degrees. We know that, in fact, the pleafantnefs of any individual concord increafes as the undulations called *beats* diminifh in frequency. It is probable that we fhall not deviate very far from the truth, if we fuppofe the harmonioufnefs of an individual tempered concord to be proportional to the flownefs of thefe undulations. But it by no means follows, that a temperate Vth and a IIId are equally pleafant, each in its kind, when they beat equally flow. There is a difference *in kind* in the pleafures of thefe concords : and this muft arife from the peculiar manner in which the component pulfes of each concord divide each other. We are certain that this is all the difference that obtains between them in Nature. But the harmonioufnefs here fpoken of is the arrangement which produces this pleafure. We are intitled to fay, that this is equal in two given inftances, when the arrangements are precifely fimilar ; and when the things arranged are the fame, nothing feems to remain in which the inftances can differ.

At any rate, it is of confequence to be able to proportion and diftribute thefe undulations at pleafure. They are unpleafant ; and when reinforced by uniting, muft be more fo. The theory puts it in our power to prevent this union : perhaps by making them very unequal ; or, if this fhould give a chance of periodical accumulation, we may find it better to make them all equal. Surely to have all this in our power is very defirable ; and this is obtained by the theory of the beats of imperfect confonances.

79 Temperament of a whole octave by beats.

But we are forgetting the procefs of tuning, and have only tuned three or four notes of our octave. We muft tune the reft by confidering their relation to notes already tuned. Thus, if g c makes 36 beats in 16 feconds, F c fhould make one third lefs, or about 24 in the fame time ; becaufe N in the formula is now 160 inftead of 240. Proceeding in this way, we fhall tune the octave C $\bar{\bar{c}}$ moft accurately as a fyftem of mean tones with perfect IIIds, by making the notes beat as follows. A point is put over the note that is to be tuned from the other, and a +, or a —, means that the concord is to be tempered fharp or flat. Thus g is tuned from c,

Make	$c\,\dot{g}$ beat	—	36 times in 16 feconds
	$\dot{G}\,c$	+	36
	$G\,\dot{d}$	—	27, *i. e.* $\frac{3}{4}$ths of $g\,c$.
	$c\,\dot{f}$	=	48

Make	$\dot{c}\,\bar{a}$ beat	+	60 times in 16 feconds
	$c\,\dot{e}$		o, *i. e.* a perfect IIId
	$d\,\dot{f}$※		o
	$\underline{e}\,\dot{g}$※		o
	$\underline{a}\,\dot{\bar{c}}$※		o
	$b^b\,\dot{f}$ downward	—	24 *i. e.* $\frac{8}{9}$ths of $c\,g$
	$\underline{b}^b\,\dot{\bar{b}}^b$		o, *i. e.* a perfect octave
	$\bar{b}^b\,\dot{e}^b$ downward	—	43, *i. e.* $\frac{6}{5}$ths of $c\,g$
	C $\dot{\bar{c}}$		o an octave.

Temperament of Scale of Mufic.

Other proceffes may be followed, and perhaps fome of them better than the procefs here propofed. Thus, b^b and e^b may be tuned as perfect IIIds to d and g downwards. Alfo, as we proceed in tuning, we can prove the notes, by comparing them with other notes already tuned, &c. &c. &c.

We have directed to tune the two notes b^b and e^b by taking the leading Vth downwards. We fhould have come at the fame pipes in the character of a※ aud d※ in the procefs of tuning upwards by Vths. But this would not have produced precifely the fame founds, although, in our imperfect inftruments, one key muft ferve for a※ and b^b. By tuning them as here directed, they are better fitted for the places in which they will be moft frequently employed in our ufual modulations.

80 Another fyftem very fit for our inftruments.

It may reafonably be afked, Why fo much is facrificed in order to preferve the IIIds perfect ? Were they allowed to retain fome part of the fharp temperament that is neceffary for preferving the Vths perfect, we fhould perhaps improve the harmony. And fince enlarging the Vth makes the tone greater, and therefore the limma *mi fa* much fmaller, it will bring it nearer to the magnitude of a half tone ; and this will be better fuited for its double fervice of the fharp of the note below, and the flat of the note above. Accordingly, fuch a temperament is in great repute, and indeed is generally practifed, although the VIths and the fubordinate chords of full harmony are evidently hurt by it. Even Dr Smith recommends it as well fuited to our defective inftruments, and gives an extremely eafy method of executing it by means of the beats. His method is to make the Vth and IIId beat equally faft, along with the key, the Vth flat, and the third fharp. He demonftrates (on another occafion), that concords beat equally faft with the fame bafs when their temperaments are inverfely as the major terms of their perfect ratios. Therefore draw EG, and divide it in p, fo that E p may be to pG as 3 to 5. Then draw C p, cutting gG in g', and E K in e'; and this temperer will produce the temperament we want. It will be found, that E e' and G g' are each of them 32 of their refpective fcales. Fig. 2.

Therefore make $c\,g$ beat 32 times in 16 feconds

G c'	32
G d	24
G b	24 and tune $b\,\bar{b}$
$\dot{d}\,\bar{a}$	36, and tune $a\,\bar{a}$
$d\,f$※	36
$a\,e$	27
$a\,\underline{c}$※	27
$e\,\bar{b}$	40 $\frac{1}{2}$, proving $b\,\bar{b}$
$e\,g$※	40$\frac{1}{2}$
F c	21$\frac{1}{3}$, and tune $F\,f$

ɪmpera-nt of the cale of Mufic.

F a	beat $21\frac{1}{5}$, proving a	
$b^b\ \underline{f}$	$28\frac{1}{5}$, and tune $b^b\ \overline{b^b}$	
$e^b\ \overline{b^b}$	$38\frac{1}{4}$	
$c\ \overline{c}$	0.	

It may be proper to add to all thefe inftructions a caution about the manner of counting the clock while the tuner is counting the beats. If this is to continue for 16 feconds, let the perfon who counts the clock fay *one* at the beat he begins with, and then telling them over *to himfelf*, let him fay *done* inftead of 17. Thus 16 intervals will elapfe while the tuner is counting the beats. Were he to begin to count at *one*, and ftop when he hears fixteen, he would get the number of beats in 15 feconds only.

81. We do not hefitate to fay, that this method of tuning by beats is incomparably more exact than by the mere judgment of the ear. We cannot miftake more than one beat. This miftake in the concord of the Vth amounts to no more than $\frac{1}{108}$th of a comma; and in the IIId it is only $\frac{1}{180}$.

82 actical truc-ns. It may be objected that it is fit only for the organ and inftruments of continued founds, but will not do for the quickly perifhing founds of the harpfichord. True, it is the only method worthy of that noble inftrument, and this alone is a title to high regard. But farther; the accuracy attainable by it, renders it the only method fit for the examination of fyftems of temperament. Even for the harpfichord it is much more exact, and more certain in its procefs, than any other. It does not proceed, by a random trial of a flattened feries of Vths, and a comparifon with the refulting IIId, and a fecond trial, if the firft be unfatisfactory. It fays at once, let the Vth beat fo many times in 16 feconds. Even in the fecond method, without counting, and merely by the equality of the beats of the Vth and IIId, the progrefs is eafy. Both are tuned perfect. The Vth is then flattened a little, and the IIId fharpened;—if the Vth beat fafter than the IIId, alter it firft.

All difficulty is obviated by the fimple contrivance of a variable pendulum, already defcribed. This may be made exact by any perfon that will take a little pains; and when once made, will ferve for every trial. When the ball is fet to the proper number, and the pendulum fet a fwinging, we can come very near the truth by a very few trials.

N. B. In tuning a piano forte, which has always two ftrings to a key, we muft never attempt tuning them both at once; the back unifon of both notes of the concord muft be damped, by fticking in a bit of foft paper behind it.

We hope that the inftructions now given, and the application of them to two very refpectable fyftems of temperament, are fufficient for enabling the attentive reader to put this method of tuning fuccefsfully in practice, and that he perceives the efficiency of it for attaining the defired end. But before we take leave of it, we beg leave to mention another circumftance, which evinces the juft value of the general theory of the beats of imperfect confonances as delivered by Dr Smith.

83 gin of Tarti-n founds. Thefe reinforcements of found, which are called *beatings*, are noifes. If any noife whatever be repeated, with fufficient frequency, at equal intervals, it becomes a mufical note, of a certain determinate pitch. If it recur 60 times in a fecond, it becomes the note C *fa ut*, or the double octave below the middle C of our harpfichords, or the note of an open pipe eight feet long. Now there is a fimilar (we may call it the very fame) reinforcement of found in every concord. Where the pulfe of one found of the concord bifects the pulfe of the other, the two founds are more uniformly fpread: but where they coincide, or almoft coincide, the condenfation of one undulation combines with that of the other, and there comes on the ear a ftronger condenfation, and a louder found. This may be called a *noife*; and the equable and frequent recurrence of this noife fhould produce a mufical note. If, for inftance, c and a are founded together: There is this noife at every third pulfe of c, and every fifth pulfe of a; that is, 80 times in a fecond. This fhould produce a note which is a 12th below c, and a 17th major below a; that is, the double octave below f, which makes 320 vibrations in a fecond. That is to fay, along with the two notes c and a of the concord, and the compound found, which we call the *concord of the VIth*, we fhould hear a third note FF in the bafs. Now this is known to be a fact, and it is the grave harmonic obferved by Romieu and Tartini about the year 1754, and verified by all muficians fince that time. Tartini prized this obfervation as a moft important difcovery, and confidered it as affording a foundation for the whole fcience of mufic. We fee that it is all included in the theory of beats publifhed five years before, namely, in 1749; and every one of thefe grave harmonics, or Tartinian founds, as they have been called, are immediate confequences of this theory. The fyftem of harmonious compofition which Tartini has, with wonderful labour and addrefs, founded on it, has therefore no folidity. It is, however, preferable to Rameau's, becaufe it proceeds on a fact founded on the nature of mufical founds; whereas Rameau's is a mere whim, proceeding on a falfe affumption; namely, "that a mufical found is effentially accompanied by its octave, 12th, and 17th *in alto*."—This is not true, though fuch accompanyment be very frequent, and it be very difficult to prevent it. Mr Rameau ought to have feen this. Are thefe acute harmonics mufical founds or not? He furely will not deny this. Therefore they, too, are effentially accompanied by *their* harmonics, and this abfolutely and neceffarily *ad infinitum*; which is certainly abfurd. We fhall have a better occafion for confidering this point when we defcribe the *Trumpet Marigni* in a future article.

We have taken notice of only two fyftems of temperament; both of them are fyftems of mean tones, and are in good repute as practicable methods. It would be almoft an endlefs tafk to mention all the fyftems of temperament which have been propofed. Dr Smith, after having, with great ingenuity, appreciated the changes of harmonioufnefs that are induced on the different concords by the fame temperament, and having affigned that proportion of temperament which renders them equally harmonious, each in its kind, gives a fyftem of temperament, which he calls EQUAL HARMONY. Each concord, (excepting the octave) is tempered in the inverfe proportion of the product of the terms of its perfect ratio. It is very nearly equivalent to a divifion of the octave into 50 equal parts. We do not give any farther account of it here, although we think its harmony preferable to any thing that we have ever heard. We heard it, as executed for him, and under his infpection, by the celebrated harpfichord-maker Kirkmann, 84 Dr Smith's fyftem of EQUAL HARMONY.

Temperament of the Scale of Mufic.

Temperament of the Scale of Muſic.

mann, both when the inſtrument was yet in the hands of the maker, and afterwards by the ingenious author. We have alſo heard ſome excellent muſicians declare, that the organ of Trinity college chapel at Cambridge was greatly improved in its harmony by the change made on its temperament under the inſpection of Dr Smith. When we name Stanley, we preſume that the authority will not be diſputed. We mention this, becauſe the writer in the Philoſophical Tranſactions ſpeaks of this ſyſtem, with flattened major thirds, as of no value. But we do not give any farther account of it, becauſe it is not ſuited to our inſtruments, which have but twelve ſounds in the octave.

85.

The reader will pleaſe to recollect, that the great object of temperament is twofold. Firſt, to enable us to tranſpoſe muſic from one pitch to another, ſo that we may make any note of the organ the fundamental of the piece. This undoubtedly requires a ſyſtem approaching to one of mean tones, becauſe the harmony muſt be the ſame in every key. This requires temperament, becauſe a ſound muſt be occaſionally conſidered, either as the ſharp of the note below it, or the flat of the one above. This cannot produce perfect harmony, becauſe the limma of the perfect diatonic ſcale is greater than a half tone. Thus a temperament is neceſſary merely for the ſake of the melody. But, *ſecondly*, the nature of modern muſic requires every note to be accompanied, or conſidered as accompanied, with full harmony. This is, in fact, the ſame thing with modulating on every different note as a fundamental; but it requires a much cloſer attention to the perfection of the intervals, becauſe a defect or exceſs in an interval that would ſcarcely offend the ear, if the notes were heard in ſucceſſion, is quite intolerable when they are ſounded together. Here the difference between the major and minor tone is of almoſt as great moment as the difference of the limma from a ſemitone. The ſecond object, therefore, is to obtain, in the compaſs of three octaves, as many good concords of full harmony; that is, conſiſting of a fundamental with its major third and its fifth, erect or inverted, as poſſible. There is no other harmony, although our notes have frequently a different ſituation and appearance.

86
Maxims of temperament very gratuitous.

It is no wonder that, in a ſubject where we are yet to ſeek for a principle, the attempts to attain this object have been very various, and very gratuitous. The mathematicians, even in modern times, have allowed themſelves to be led away by fancies about the ſimplicity and conſequent perfection of ratios; and having no clear principle, it is no wonder that ſome of their deductions are contrary to experience. According to Euler, thoſe ratios which are moſt perfect, that is, moſt ſimple, admit of leaſt temperament. The octave is therefore infinitely perfect; for it is allowed by all, that it muſt not have the ſmalleſt temperament. A Vth muſt be leſs tempered than a IIId. Even the practical muſician thinks that he has tempered theſe two concords equally, when the offenſive quality of each is made equally ſo; but in this caſe it is demonſtrable, that the Vth has been much more tempered than the IIId. But this could not be diſcovered till we got the theory of beats.

Moſt of the mathematical muſicians adhered to ſyſtems of mean tones; or, which are equivalent, to ſuch ſyſtems, giving ſimilar harmonies on every key of the harpſichord. This is ſurely the moſt natural, and is peculiarly ſuggeſted by the tranſpoſing of muſic from one pitch to another: but they differ exceedingly, and without giving any convincing arguments, in their eſtimation of the effects of the ſame temperament on different concords. Much of this, we apprehend, ariſes from diſpoſition. Perſons of a gay diſpoſition reliſh the harmony of the IIId, and prefer a ſharp to a flat temperament of this concord. Perſons of a more penſive diſpoſition, prefer ſuch temperaments as allow the minor thirds to be more perfect.

87
Equal harmony rejected.

But there are many, eminent both as performers and as theoriſts, who reject any ſyſtem which gives the ſame harmonies on every note of the octave. They obſerve, that in the progreſs of the cultivation of muſic in Europe, the melodies of all nations have gradually approached to a certain uniformity. Certain cadences, cloſes, ſtrains, and phraſes, are becoming every day more common; and even in the conduct of a conſiderable piece of muſic, and the gradual but ſlow paſſage of the modulation from one key into another, there is a certain regularity. Nay, they add, that this cannot be greatly deviated from without becoming very offenſive. We may remain ignorant of the cauſe of this uniformity; but its exiſtence ſeems to prove that it ariſes from ſome natural principle; and therefore it ought to be complied with, and our temperaments ſhould be accommodated to it. The reſult of this uniformity in the muſic of our times is, that the modulation on ſome keys is much leſs frequent than on others, and this frequency decreaſes in a certain order. Suppoſing that we begin on C. A piece of plain muſic ſeldom goes farther than G and F. A little more fancy and refinement leads the compoſer into D, or into B^b, &c. &c. It would therefore be deſirable to adjuſt our temperaments ſo, that the harmonies in C ſhall be the beſt poſſible, and gradually leſs perfect in the order of modulation. Thus we ſhall, in our general practice, have finer harmony than if it were made equal throughout the octave; becauſe the unavoidable imperfections are thrown into the leaſt frequented places of the ſcale. The practical muſicians add to this, that by ſuch a temperament the different keys acquire characters, which fit each of them more particularly for the expreſſion of different ſentiments, and for exciting different emotions. This is very perceptible in our harpſichords as they are generally tuned. The major key of A is remarkably brilliant; that of F is as remarkably ſimple, &c.

We cannot ſay that we are altogether convinced by theſe arguments. The violin is unqueſtionably the inſtrument of the greateſt powers. A concert of inſtruments of this kind, unembarraſſed by the harpſichord, or any inſtruments incapable of occaſional temperament, is the fineſt muſic we have. The performers make no ſuch degradations of harmony, but keep it as perfect as poſſible throughout; and a violin performer is ſenſible of violence and conſtraint when he accompanies a keyed inſtrument into theſe unfrequented paths. Let him play the ſame muſic alone, and he will play it quite differently, and much more to his own ſatisfaction. We imagine, too, that much of the uniformity ſpoken of is the reſult of imitation and faſhion, and even of the temperaments that we have preferred. There is an evident diſtinction in the native muſic of different nations. An experienced muſician will know, from a few bars, whether

Tempera-ent of the Scale of Music.

ther an air is Irish, Scotch, or Polish. This distinction is in the modulation; which, in those nations, follows different courses, and should therefore, on the same principle, lead to different temperaments.

With respect to the variety of characters given to the different keys, we must acknowledge the fact. We have tuned a piano forte in the usual manner; but instead of beginning the process with C, we began it with D. An excellent performer of voluntaries sat down to the instrument, and began to indulge his rich fancy; but he was confounded at every step: he thought the instrument quite out of tune. But when he was informed how it had been tuned, and then tried a known plain air on it, he declared it to be perfectly in tune. It is still very doubtful, however, whether we should not have much finer music, by equalising the harmony in the different keys, and trusting for the different expression so much spoken of to a judicious mixture of other notes called *discords*.

88
ause of is uncer-inty ow re-oved by r Smith's eory.

After all, the great uncertainty about the most proper temperament has remained so long undetermined, because we had no method of executing with certainty any temperament that was offered to the public. What signifies it on what principle it may be proper to flatten a Vth one-fifth of a comma, and sharpen a VIth one-seventh of a comma, unless we are able to do both the one and the other? Till Dr Smith published the theory of beats, the monochord was the only assistance we had: but however nicely it may be divided, it is scarcely possible to make the moveable bridge so steady and so accurate in its motion, that it will not sensibly derange the tension of the string. We have seen some very nice and costly monochords; but not one of them could be depended on to one-eighth of a comma. Even if perfect, they gave but momentary sounds by pinching. The bow cannot be trusted, because its pressure changes the tension. Mr Watt's experiments with his monochord of continued sound shewed this evidently. A pitch-pipe with a sliding piston promises the greatest accuracy; but we are sadly disappointed, because the graduation of the piston cannot be performed by any mathematical rule. It must be pushed more than half way down to produce the octave, more than one-third to produce the Vth, &c. and this without any rule yet discovered. Thanks to Dr Smith we can now produce an instrument tuned exactly, according to any proposed system, and then submit it to the fair examination of musicians. Even the speculatist may now form a pretty just opinion of the merits of a system, by calculating, or measuring by such scales as we have proposed, the beats produced by the tempered concords in all parts of the octave. No one who has listened with attention to the rattling beats of a full organ, with its twelfth and sesquialter stops all sounding, will deny that they are hostile to all harmony or good music. We cannot be much mistaken in preferring any temperament in proportion as it diminishes the number of those beats. We should therefore examine them on this principle alone; attending more particularly to the beats of the third major, because these are in fact the loudest and most disagreeable: and we must not content ourselves with the beats of each concord with the fundamental of the full harmony, whether K—III—V, or K—4—VI, or K—3—V, or K—4—6, which sometimes occurs. We must attend equally to the beats of the two notes of accompanyment with each other: these are generally the most faulty.

Temperament of the Scale of Music.

89.

This examination is neither difficult nor tedious. 1. Write down, in one column, the lengths of the strings or divisions of the monochord; in another write their logarithms; in a third the remainders, after subtracting each from the logarithm of the fundamental. 3. Have at hand a similar table for the perfect diatonic scale. 4. Compare these, one by one, and note the difference, + or —, in a 4th column. These are the temperaments of each note of the scale. 5. Compare every couple of notes which will compose a major or minor third, or a fifth, by subtracting the logarithm of the one note from that of the other. The differences are the intervals tempered. 6. Compare these with the perfect intervals of the diatonic scale, and note the differences, + or —, and set them down in a fifth column. These are all the temperaments in the system. 7. If we have used logarithms consisting of five decimal places, which is even more than sufficient, consider these numeral temperaments as the q of the formula given in nº 65. for calculating the beats, and then p is always $= 540$. Or we may make another column, in which the temperaments are reduced to some easy fraction of a comma.

90
System of Dr Young.

We shall content ourselves with giving one example; of the temperament proposed by Mr Young in the Philosophical Transactions for 1800. It is contained in the following table:

1.	2.	3.	4.	5.		
				IIIds upward on		
C	100000	5.00000		C	135	
C※	94723	4.97645	2355	G. F.	190	
D	89304	4.95087	4913	D. B♭	245	
E♭	83810	4.92330	7670	A. E♭	346	Sharp.
E	79752	4.90174	9826	E. A♭	448	
F	74921	4.87461	12539	B. C※	494	
F※	71041	4.85151	14849	F※	540	
G	66822	4.82492	17508	3ds upward on		
G※	63148	4.80036	19964	A. E.	236	
A	59676	4.77580	22420	D. B.	291	
B♭	56131	4.74921	25079	G. F※	346	
B	53224	4.72610	27390	C. C※	448	Flat.
C	50000	4.69897	30103	F. G※	494	
				B♭ E♭	540	

Vths upward on

E♭. G※. C※. F※	perfect	
F. B♭. E. B	46	Flat.
C. G. D. A	116	

Interval of a comma	540
minor third . . .	7918
major third . . .	9691
fifth	17609

The first column of the above table contains the ordinary designations of the notes. The second contains the corresponding lengths of the monochord. The third contains the logarithms of column second. The fourth contains the difference of each logarithm from the first. The next column contains, first, the temperaments of all the major thirds, having for their lowest note the sound corresponding to the letter. Thus 494, or $\frac{494}{540}$ of a comma, Temperament of the Scale of Muſic, Templars.

comma, is the temperament of the IIId, B — D※, and C※ — F. Secondly, it contains all the minor thirds formed on the notes repreſented by the letters. The column below contains the temperaments of the Vths. *N. B.* Theſe temperaments are calculated by the author. We have found ſome of them a little different. Thus we make the temperament of C — G only 108. Below this we have ſet down the meaſures of the perfect intervals, which are to be compared with the differences of the logarithms in column third.

91 Syſtem of Kirnbergher.

We preſume not to decide on the merits of this temperament: Only we think that the temperaments of ſeveral thirds, which occur very frequently, are much too great; and many inſtances of the 6th, which is frequent in the flat key, are ſtill more ſtrongly tempered. A temperament, however, which very nearly coincides with Dr Young's, has great reputation on the continent. This is the temperament by Mr Kirnbergher, publiſhed at Berlin in 1771, in his book called *Die Kunſt des reinen Satzes in der Muſik*. The eminent mathematician Major Templehoff has made ſome important obſervations on this temperament, and on the ſubject in general, in an eſſay publiſhed in 1775, Berlin. Dr Young's is certainly preferable.

The monochord is thus divided by Kirnbergher:

C =	1,0000	F =	7500	B♭ =	5625
C※	9492	F※	7111	B	5313
D	8889	G	6667	*c*	5000
E♭	8437	G※	6328		
E	8000	A	5963		

We conclude this article (perhaps too long) by earneſtly recommending to perſons who are not mathematically diſpoſed, the ſliding ſcales, either circular or rectilineal, containing the octave divided into 301 parts; and a drawing of fig. 2. on card paper, of proper ſize, having the quarter comma about two inches, and a ſeries of ſcales correſponding to it. This will ſave almoſt the whole of the calculation that is required for calculating the beats, and for examining temperaments by this teſt. To readers of more information, we earneſtly recommend a careful peruſal of Smith's Harmonics, ſecond edition. We acknowledge a great partiality for this work, having got more information from it than from all our patient ſtudy of the moſt celebrated writings of Ptolemy, Huyghens, Euler, &c. It is our duty alſo to ſay, that we have got more information concerning the muſic of the Greeks from Dr Wallis's appendix to his edition of Porphyrius's Commentary on Ptolemy's Harmonics, than from any other work.

TEMPLARS. In the account of this order, which is publiſhed in the *Encyclopædia*, we have, with many others, ſuppoſed that the guilt of which they were accuſed at the ſuppreſſion of the order was leſs enormous than their enemies alleged. For the honour of human nature, we are ſtill unwilling to believe that this was not the caſe. Juſtice, however, compels us to admit, that the Abbé Barruel has brought together ſuch a cloud of witneſſes againſt the Templars, that we know not how to reſiſt their evidence; and that he has completely proved that *Philip le Bel* was not influenced by avarice when he ſuppreſſed that order in France. "It has been ſaid that he and Clement V. had concerted between them the diſſolution of the Templars. The falſity of ſuch an aſſertion is evident on the inſpection of their letters. Clement V. at firſt will give no credit to the accuſations againſt the Templars; and even when he receives inconteſtable proofs from Philip le Bel, he had ſtill ſo little concerted the plan with that Prince, that every ſtep taken by the one or the other occaſions diſputes on the rights of the church or of the throne.

Templars.

"It was alſo ſaid, that the king wiſhed to ſeize on the great riches of theſe knights: but at the very commencement of his proceedings againſt the order, he ſolemnly renounced all ſhare in their riches; and perhaps no prince in Chriſtendom was truer to his engagement. Not a ſingle eſtate was annexed to his domain; and all hiſtory bears teſtimony to the fact.

"We next hear of a ſpirit of revenge which actuated this prince; and during the whole courſe of this long trial, we do not hear of a ſingle perſonal offence that he had to revenge on the Templars. In their defence, not the moſt diſtant hint, either at the revengeful ſpirit, or at any perſonal offence againſt the king, is given; ſo far from it, until the period of this great cataſtrophe, the grand maſter of the order had been a particular friend of the king's, who had made him godfather to one of his children.

"In fine, the rack and torture is ſuppoſed to have forced confeſſions from them which otherwiſe they never would have made: and in the minutes, we find the avowal of at leaſt 200 knights all made with the greateſt freedom, and without any coercion. Compulſion is mentioned but in the caſe of one perſon; and he makes exactly the ſame avowal as 12 other knights, his companions, freely made (A). Many of theſe avowals were made in councils where the biſhops begin by declaring, that all who had confeſſed through fear of the torture ſhould be looked upon as innocent, and that no Knight Templar ſhould be ſubjected to it (B). The Pope Clement V. was ſo far from favouring the king's proſecutions, that he began by declaring them all to be void and null. He ſuſpended the archbiſhops, biſhops, and prelates, who had acted as inquiſitors in France. The king accuſes the Pope in vain of favouring the Templars; and Clement is only convinced after having been preſent at the interrogatories of 72 knights at Poictiers, in preſence of many biſhops, cardinals, and legates. He interrogated them, not like a judge who ſought for criminals, but like one who wiſhed to find innocent men, and thus exculpate himſelf from the charge of having favoured them. He hears them repeat the ſame avowals, and they are freely confirmed. He deſired that theſe avowals ſhould be read to them after an interval of ſome days, to ſee if they would ſtill freely perſevere in their depoſitions. He hears them all confirmed. *Qui perſeverantes in illis, eas expreſſe et ſponte prout recitatæ fuerant approbârunt.* He wiſhed ſtill further to interrogate the grand maſter and the principal ſuperiors, *præceptores majores*, of the divers provinces of France, Normandy, Poitou, and of the Tranſmarine countries. He ſent the moſt venerable perſons to interrogate thoſe of the ſuperiors, whoſe age or infirmities hindered them from

(A) *Layette*, No. 20. *Interrog. made at Caen.*
(B) See the *Council of Ravenna. Rubeus Hiſt. Raven.* lib. vi.

Templars. from appearing before him. He ordered the depofitions of their brethren to be read to them, to know if they acknowledged the truth of them. He required no other oath from them than to anfwer freely and without compulfion; and both the grand mafter and the fuperiors of thefe divers provinces, depofe and confefs the fame things, confirm them fome days after, and approve of the minutes of their depofitions taken down by public notaries. Nothing lefs than fuch precautions could convince him of his error: it was then only that he revoked his menaces and his fufpenfion of the French bifhops, and that he allows the king to proceed in the trials of the Templars.

"Let fuch pretexts be forgotten, and let us only dwell on the avowals which truth alone forced from thefe criminal knights.

"Their depofitions declare, that the Knights Templars, on their reception, denied Chrift, trampled on the crofs, and fpit upon it; that Good Friday was a day which was particularly confecrated to fuch outrages; that they promifed to proftitute themfelves to each other for the moft unnatural crimes; that every child begotten by a Templar was caft into the fire; that they bound themfelves by oath to obey, without exception, every order coming from the grand mafter; to fpare neither facred nor prophane; to look upon every thing as lawful when the good of the order was in queftion; and, above all, never to violate the horrible fecrets of their nocturnal myfteries, under pain of the moft terrible chaftifements (c).

"In making their depofitions, many of them declared they had only been forced into thefe horrors by imprifonment and the moft cruel ufage; that they wifhed, after the example of many of their brethren, to pafs into other orders, but that they did not dare, fearing the power and vengeance of their order; that they had fecretly confeffed their crimes, and had craved abfolution. In this public declaration, they teftified, by their tears, the moft ardent defire of being reconciled to the church.

"All repeat the fame depofition, except three, who declare they have no knowledge of the crimes imputed to their order. The Pope, not content with this information taken by men of religious orders and by French noblemen, requires that a new trial fhould take place in Poitou before cardinals and others whom he himfelf nominates: Again, with the fame freedom, and for the third time, the grand mafter and other chiefs, in prefence of Clement V. repeat their depofitions. Molay even requefted, that one of the lay brothers, who was about his perfon, fhould be heard, and this brother confirms the declaration. During many years thefe informations were continued and renewed at Paris, in Champagne, in Normandy, in Quercy, in Languedoc, in Provence. In France alone, above 200 avowals of the fame nature are to be found: nor did they vary in England, where, at the fynod of London held in 1311, 78 Englifh knights were heard and two whole months were fpent in taking informations and in verifying their declarations. Fifty-four Irifh were alfo heard, and many Scotch, in their refpective countries. It was in confequence of thefe declarations that the order of the Templars was abolifhed in thofe kingdoms, and that the parliament difpofed of their goods (D). The fame declarations were taken and proved in Italy, at Ravenna, at Bologna, at Pifa, and at Florence, though in all thefe councils the prelates were very ready to abfolve all thofe knights who could fucceed in their juftifications. Templars, Templeman.

"I would willingly affert (continues the Abbé), that it was the fmaller part of the Templars who fuffered themfelves to be carried away by fuch abominations. Some even at Paris were declared innocent. In Italy a ftill greater number were abfolved; of all thofe who were judged at the councils of Mayence and Salamanca, none were condemned: and hence we may conclude, that of the 9000 houfes belonging to the order, many had not been tainted, and that whole provinces were to be excepted from the general ftain of infamy. But the condemnations, the juridical depofitions, the method of initiating the knights, almoft became general; the fecrecy of their receptions, where neither prince, nor king, nor any perfon whatever, could be prefent during the laft half century, are fo many teftimonies which corroborate the divers accufations contained in the articles fent to the judges; that is to fay, that at leaft two-thirds of the order knew of the abominations practifed without taking any fteps to extirpate them. *Quod omnes, vel quafi duæ partes ordinis fcientes dictos errores corrigere neglexerint.*

"This certainly cannot mean that two thirds of the knights had equally partaken of thefe abominations. It is evident, on the contrary, that many detefted them as foon as they were acquainted with them; and that others only fubmitted to them, though initiated, after the harfheft treatment and moft terrible threats. Neverthelefs, this proves, that the greateft part of thefe knights were criminal, fome through corruption, others through weaknefs or connivance; and hence the diffolution of the order became neceffary."

TEMPLEMAN (Peter). M. D. the fon of an eminent attorney at Dorchefter in the county of Dorfet, by Mary daughter of Robert Haynes, was born March 17, 1711, and was educated at the Charter-houfe (not on the foundation), whence he proceeded to Trinity-college, Cambridge, and there took his degree of B. A. with diftinguifhed reputation. During his refidence at Cambridge, by his own inclination, in conformity with that of his parents, he applied himfelf to the ftudy of divinity, with a defign to enter into holy orders; but after fome time, from what caufe we know not, he altered his plan, and applied himfelf to the ftudy of phyfic. In the year 1736, he went to Leyden, where he attended the lectures of Boerhaave, and the profeffors of the other branches of medicine in that celebrated univerfity, for the fpace of two years or more. About the beginning of 1739, he returned to London, with a view to enter on the practice of his profeffion, fupported by a handfome allowance from his father. Why he did not fucceed in that line was eafy to be accounted for by thofe who knew him. He was a man of a very liberal *Biog. Dict.*

(c) See the *Vouchers brought by Dupuy*, and *Extract of the Regifters*.

(D) Vide *Valfinger in Edvardum* II. *et Ypodigma Neuftriæ apud Dupuy.—Effai de Fred. Nicolai.*

liberal turn of mind, of general erudition, with a large acquaintance among the learned of different profeſſions, but of an indolent, inactive diſpoſition; he could not enter into juntos with people that were not to his liking; nor cultivate the acquaintance to be met with at tea-tables; but rather choſe to employ his time at home in the peruſal of an ingenious author, or to ſpend an attic evening in a ſelect company of men of ſenſe and learning. In this he reſembled Dr Armſtrong, whoſe limited practice in his profeſſion was owing to the ſame cauſe. In the latter end of the year 1750 he was introduced to Dr Fothergill by Dr Cuming, with a view of inſtituting a Medical Society, in order to procure the earlieſt intelligence of every improvement in phyſic from every part of Europe. At the ſame period he tells his friend, "Dr Mead has very generouſly offered to aſſiſt me with all his intereſt for ſucceeding Dr Hall at the Charter houſe, whoſe death has been for ſome time expected. Inſpired with gratitude, I have ventured out of my element (as you will plainly perceive), and ſent him an ode." Dr Templeman's epitaph on Lady Lucy Meyrick (the only Engliſh copy of verſes of his writing that we know of), is printed in the eighth volume of the "Select Collection of Miſcellany Poems, 1781." In 1753 he publiſhed the firſt volume of "Curious Remarks and Obſervations in Phyſic, Anatomy, Chirurgery, Chemiſtry, Botany, and Medicine; extracted from the Hiſtory and Memoirs of the Royal Academy of Sciences at Paris;" and the ſecond volume in the ſucceeding year. A third was promiſed, but we believe never printed. It appears, indeed, that if he had met with proper encouragement from the public, it was his intention to have extended the work to twelve volumes, with an additional one of index, and that he was prepared to publiſh two ſuch volumes every year. His tranſlation of "Norden's Travels" appeared in the beginning of the year 1757; and in that year he was editor of "Select Caſes and Conſultations in Phyſic, by Dr Woodward," 8vo. On the eſtabliſhment of the Britiſh Muſeum, in 1753, he was appointed to the office of keeper of the reading-room, which he reſigned on being choſen, in 1760, ſecretary to the then newly inſtituted Society of Arts, Manufactures, and Commerce. In 1762, he was elected a correſponding member of the Royal Academy of Science of Paris, and alſo of the Œconomical Society at Berne. Very early in life Dr Templeman was afflicted with ſevere paroxyſms of an aſthma, which eluded the force of all that either his own ſkill, or that of the moſt eminent phyſicians then living, could ſuggeſt to him; and it continued to haraſs him till his death, which happened September 23, 1769. He was eſteemed a man of great learning, particularly with reſpect to languages; ſpoke French with great fluency, and left the character of a humane, generous, and polite member of ſociety.

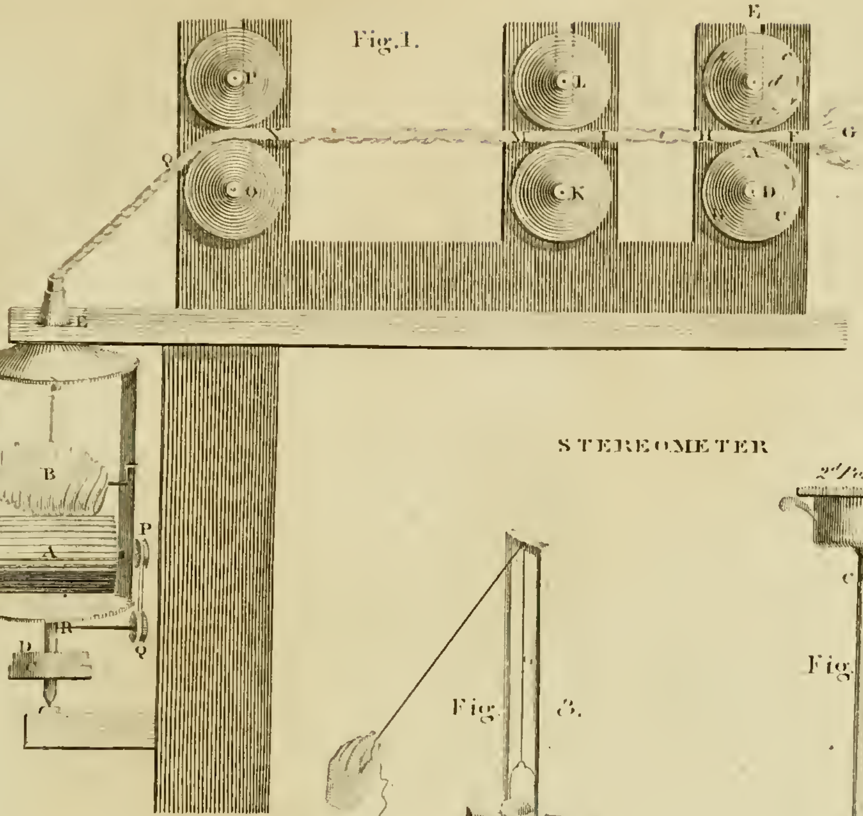
TERANE', a town in Egypt, ſituated on what Mr Browne calls the *left* of the moſt weſtern mouth of the Nile, at a very ſmall diſtance from the river. Its latitude is 30° 24′. The buildings are chiefly unburned brick, though there are alſo ſome of ſtone. The town and diſtrict, containing ſeveral villages, belonged, before the French invaſion, to Murad Bey, who uſually entruſted its government, and the collection of its revenue, to one of his Caſhefs. That revenue ariſes principally from natrôn (See. NATRUM, *Encycl.*), found in great quantities in certain lakes about thirty five miles from Terané; and it is on account of theſe lakes only that the town is worthy of notice in this work; for though there are many columns in its neighbourhood, which indicate the ſite of ancient ſtructures, none of them have inſcriptions aſcertaining their antiquity.

The eaſtern extremity of the moſt weſtern lake Mr Browne found to be 30° 31′ North. No vegetation appears, except reeds, on the margin of the lake, which is very irregular in its form; ſo that it is not eaſy to ſay what may be the quantity of ground covered with water. It is higher in winter than in ſummer; and when it was viſited by our author its breadth did not exceed a mile, though its length was nearly four. Towards the end of the ſummer, it is ſaid theſe lakes are almoſt dry; and the ſpace that the water has retired from is then occupied by a thick depoſition of ſalt. Not far removed from the eaſtern extremity, a ſpring riſes with ſome force, which much agitates the reſt of the water. Cloſe to that ſpring the depth was far greater than Mr Browne's height; in other parts it was obſervable that it did not generally exceed three feet. The thermometer near this ſpring ſtood at 76, while in the open air it was 87. The more weſtern lake differs not materially from the eaſtern in ſize, form, or productions. The colour of the water in both is an imperfect red; and where the bottom is viſible, it appears almoſt as if covered with blood. Salt, to the thickneſs of five or ſix inches, lies conſtantly in the more ſhallow parts. The ſurface of the earth, near the lake, partakes more or leſs generally of the character of natrôn, and, in the parts fartheſt removed, offers to the foot the ſlight reſiſtance of ploughed ground after a ſlight froſt. The ſoil is coarſe ſand. The water of the lake, on the ſlighteſt evaporation, immediately depoſits ſalt. There is a mountain not far from the lakes, where natrôn is found in inſulated bodies, near the ſurface, of a much lighter colour than that produced in the lake, and containing a greater portion of alkali. How thick the ſubſtance of natrôn commonly is in the lake, our author did not accurately determine; but thoſe employed to collect it report, that it never exceeds a cubit, or common pike; but it appears to be regenerated as it is carried away. If ever it ſhould be brought to ſuperſede the uſe of barilla, the quantity obtainable ſeems likely to anſwer every poſſible demand.

TEREBRATULÆ (ANOMIÆ, *Lin.* ſee that article *Encycl.*) have been ſuppoſed not to exiſt now but as petrified ſhells. This, however, is a miſtake. The anomia is an inhabitant of every region, and has exiſted in every age. As many terebratulæ were caught by Perouſe's people during his voyage of diſcovery, and as Lamanon the naturaliſt thought they ſhould be conſidered as a genus by themſelves, he has given us the following deſcription of the *anomia*, or, as he calls it, *terebratula*, on the coaſt of Tartary:

The length of the ſhell varies from ſix to twenty lines, and its breadth from five to eighteen; there are, however, conſiderable varieties of proportion between different individuals, beſides thoſe ariſing from the different ages of the animal. It would be improper, therefore, to diſtinguiſh the various ſpecies of anomiæ by the proportion of their ſhells. The waving lines on the edges of the ſhell are equally defective, as diſtinctive

Fig.1.



STEREOMETER

Fig. 1.

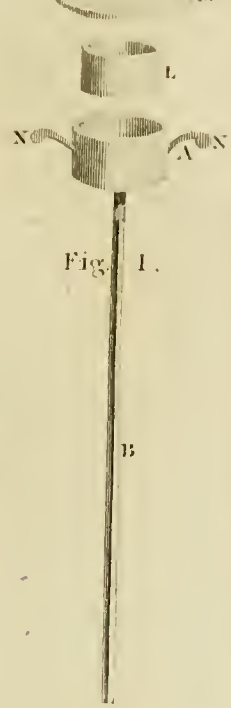


Fig. 2.

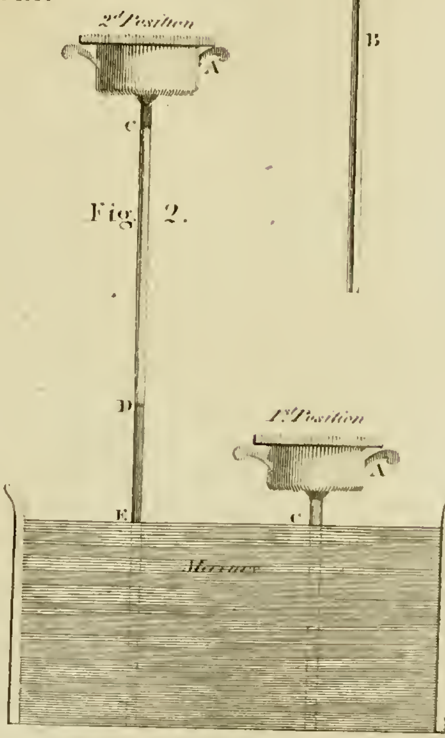
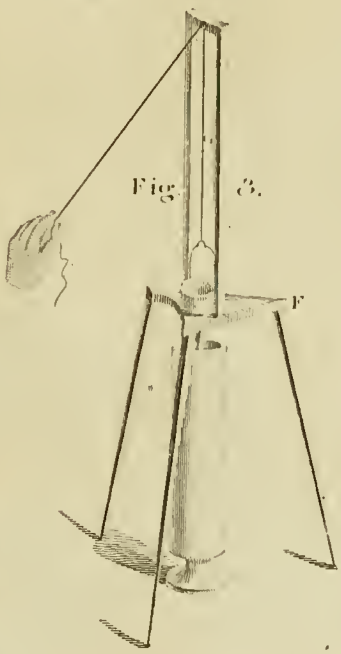


Fig. 3.



VEGETABLE SUBSTANCES

Fig.1.

Fig.2.

TEREBRATULA

Fig.1.

Fig.2.

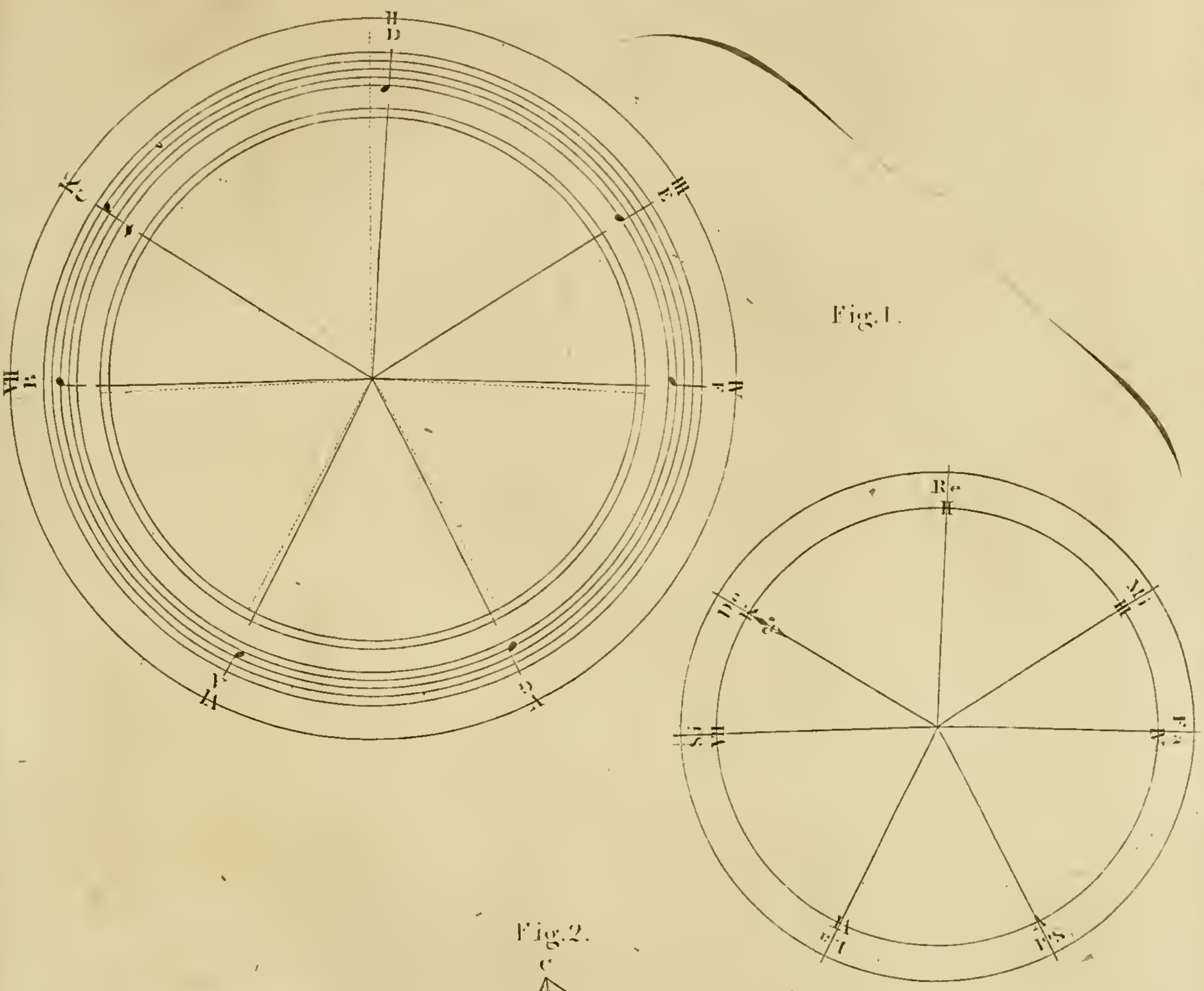

D
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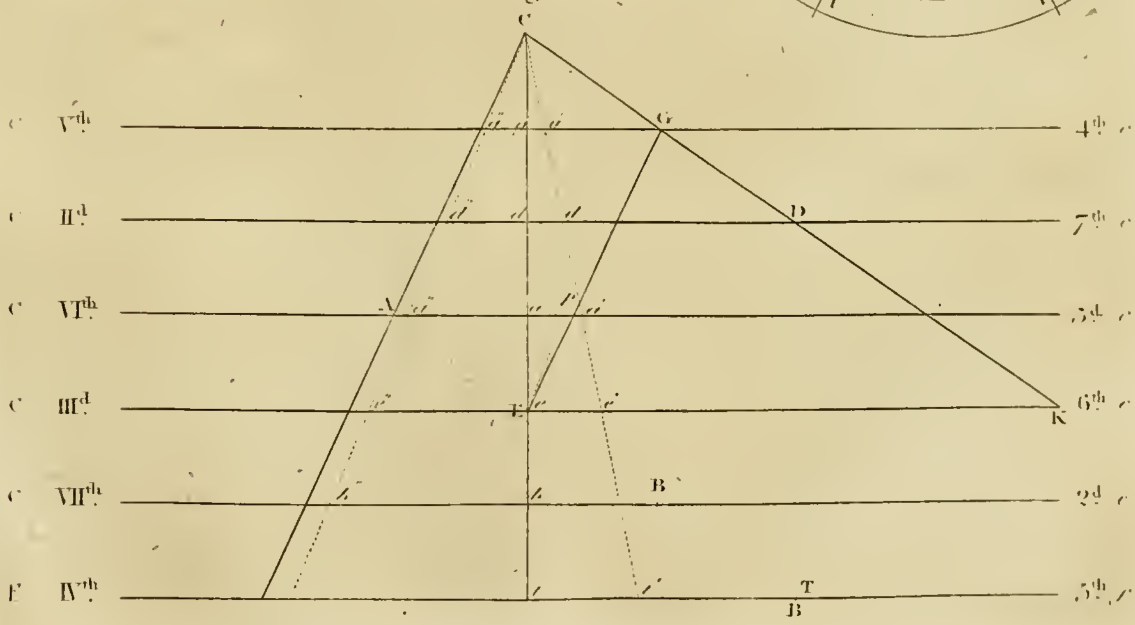
Fig.1.

Fig.2.


C
G
D
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E
K
B
T
B
C Vth
C IId
C VIth
C IIId
C VIIth
F IVth
4th
7th
3d
6th
2d
5th

Terebratulæ.

stinctive characters; for our author observed in the same species the shell approaching or receding indifferently from the circular form, and, in some, the edges of the valves are on the same plane; whereas in others, one of the valves forms a salient angle in the middle of its curve, and the other a re-entering angle.

The shell is of a moderate thickness, about that of a common muscle; it is somewhat transparent, convex like the cockle: neither of the shells is more sensibly arched than the other; that, however, which has the spur, is rather the most so, especially in the superior part.

On the surface of the shell are seen a number of slight transverse depressions, of a semicircular waved form, which reach the part where the shell ceases to be circular, in order to form the angle which supports the summit.

These striæ are covered with a very thin and slightly-adhering periosteum; in some specimens there are from one to three shallow broad depressions, radiating insensibly from the centre of the shell, and becoming more marked as they approach the edges, where they form, with the corresponding parts of the other shell, those salient and re-entering angles which have been mentioned. The periosteum is rather more firmly fixed on the latter angles than on the former.

The shells are equal in the rounded part of their edge, and close very exactly; however, towards the summit, the spur of one of the shells reaches considerably beyond the other shell, consequently they are unequal, as in oysters.

The spur, or summit, is formed by the folding from within of the edge of the shell, and the elongation of its upper part. The folded edges form an oval aperture of a moderate size, through which the animal extends the muscle, by means of which it attaches itself to other substances. This shell is not, therefore, perforated, as its name of terebratula would seem to imply, the opening not being worked in one of the shells, but formed by the elongation of one shell, the folding in of its edges, and the approach of the other shell. The summit is not pointed, but round.

The ligament, as in the oyster, is placed between the summits, and does not appear on the outside; it adapts itself to the pedicle of the animal. As the summit takes up a considerable part of the shell, the valves are only capable of opening a very little without running the risk of being broken. It is very firm, though slender, and not easily to be discovered, being fixed in a small groove, which is filled up when the shell is shut by the corresponding part of the opposite shell. This ligament preserves its texture, even for a considerable time after the shell is emptied and become dry.

Oysters are without a hinge, the teeth which form it in many other shells not existing in them. The anomia has been considered as an oyster, because its hinge or teeth have not been examined: they are not visible indeed in the fossil specimens; but in opening them when alive, the teeth composing the hinge are sufficiently visible, being even much larger than in the greater part of bivalve shells. The fossil terebratulæ are almost always found with their shells closed; whereas the other bivalves have usually theirs either open or separated: the reason of this seems to arise from the nature of the hinge, that of the anomia not allowing it to separate, and the ligament, which is very tight, contributing to keep the two shells united. The teeth which form the hinge of the anomia approach very near to those of the *spondyle*, described by M. Adanson. In this last they are formed by two rounded projections, and in the anomia by the same a little elongated. It is above these teeth that the ligament is placed in the larger shell: there are between it and the teeth two cavities, one on each side, which serve to receive the teeth of the other valve. The teeth of the larger shell have, besides, a slight projection, which fits into a longitudinal furrow in the other shell in front of the teeth.

The substance which covers the inside of the shell holds, as in oysters, a middle place between *nacre* and the interior substance of shells, which are destitute of it. The degree of its lustre, polish, and thickness, varies with the age and circumstances of individuals.

The colour of the teeth is always white; that of the outer surface of the shell verges more or less to the ochry red, especially on the border. The inside has also a very slight tint of this colour, on a varying greyish-white ground.

There is visible on each side of the shell the impression of two very distinct tendons; a circumstance which forms a very essential difference between this genus and that of the oyster: this latter having only one tendon arising from the middle of the body. The impressions of the tendon in the largest shell are oblong, situate near the summit, and hollowed; each of them has curved transverse ridges, divided into two parts by a longitudinal furrow, representing the wings of certain insects. In the other valve the insertions have a different form; their situation is the same, but they are very irregularly rounded and encompassed by two fulcations, which are separated from each other by an intervening ridge, and then are continued in a right line towards the opening of the shell as far as about two thirds of its length. That part of the summit of the shell along which the pedicle of the animal passes, is longitudinally striated in the larger shell, of which the middle stria is the deepest: the longitudinal striæ are divided into equal parts by a transverse depression. There are no similar marks on the other shell.

Our author dissected the animal itself, and found what he calls the *manteau* of the anomia, formed of a very fine membrane, lining the inside of both shells, and containing the body of the animal. Its origin is of the same breadth as the hinge of the shell, whence it divides into two lobes, lining both the shells: it forms, therefore, only a single aperture, terminating at each end of the hinge, and of the same breadth with the interior surface of the shell: it appears to have only one trachea, which is formed by the two lobes of the manteau.

Our naturalist having opened the shell, divided the ligament as delicately as possible, unfixed the hinge, and detaching from the larger shell the lobe of the manteau, turned over the body of the animal. This operation exposed to view the large muscles which adhered to the shell; they are soft, membranous, and, as it were, fleshy on the inside, being covered with small sanguiferous glands. From the lower part of each muscle there proceeds a pretty strong tendon, which reaches to the extremity of the manteau; they run parallel to the edge of the shell, and at a considerable distance from each other; and are each enclosed in a sort of flatted sac, of the

the ſhape of a ribbon, which is filled with a red viſcid matter. It appears that the place of inſertion of the muſcles, as well as the muſcles themſelves, which extend along the lob of the manteau, furniſh real blood, which is contained in three ſmall fleſhy red glandular bodies of unequal ſize, which are viſible after having taken off the muſcles; perhaps theſe conſtitute the heart of the animal.

The muſcles which are inſerted into the other ſhell are alſo divided into ſeveral parts; ſome are ſeen extending along the correſponding lobe of the manteau; many others riſe up in a kind of tuft, which is fixed into the ſhell above: ſome again ſubdivide into ſuch minute ramifications as not to allow of tracing their courſe, even with the aſſiſtance of a microſcope; but others, more apparent, contribute to the formation of the pedicle which paſſes through the opening left between the two ſhells, is connected to each of them by ſeveral fibres, and fixes itſelf to ſome external body, principally to other bivalves. The muſcles of the anomia have therefore three attachments, namely, to the inner ſurface of each ſhell, and to ſome external body.

The form of the pedicle is cylindrical, being encloſed in a muſcular ſubſtance, which contains ſeveral fibres; it is from a line to a line and a half long, and two thirds in diameter. It adheres ſo forcibly to different ſubſtances, as that the animal, and all the muſcles which contribute to the formation of the pedicle, may more eaſily be torn through than the pedicle detached from the place of its adheſion. The gluntinous ſubſtance which connects them to each other, reſiſts even the heat of boiling water. It is by means of this pedicle that the animal raiſes its ſhell ſo as to be, while in the water, in a poſition inclined to the horizon. The ſmalleſt valve is always the loweſt, being that upon which the animal reſts; the ſuperior one being the larger, and ſerving as a covering. Our author thinks the animal has the power of loco-motion.

After raiſing the lobe of the manteau he obſerved the ears. They are large, compoſed of two membranaceous laminæ on each ſide, of which the ſuperior is the narrower. Theſe laminæ are connected to each other by a thin membrane, ſo as to form only a ſingle pouch. They have on their edges long fringes, which hang looſe upon the manteau; but a very remarkable circumſtance is, that their ears are ſupported by little bones like thoſe of fiſh. The form of the ears is that of an arch; they are ſeparated from each other on their lower part, where the fringes are the longeſt; ſo that the two ears on one ſide are perfectly diſtinct from thoſe on the other ſide. The commencement of the ears is at the teeth of the hinge.

Between the ears are ſituate the ſtomach, œſophagus, and mouth; the whole forming a triangle, of which the mouth is the baſe. It is placed at the ſide of the hinge, and conſiſts of a large tranſverſe opening without lips or jaw-bone. The œſophagus is very ſhort, but is capable of elongation when the animal opens its mouth. The ſtomach, which is of the ſhape of a pointed ſac, is connected by a membrane to the bones of the ear. On opening the ſtomach, he found a ſmall ſhrimp half digeſted.

At the bottom of the ſtomach is ſeen the inteſtine, of which it is, as it were, a continuation. It is extremely ſhort, not exceeding half a line in a ſhell fifteen lines acroſs, and is compoſed of a very ſlender membrane. The excrements are diſcharged upon the lobes of the manteau, but they are eaſily thrown out by the motions of the two lobes.

The little bones of the ears, already mentioned, had not formerly been obſerved in any of the teſtaceous animals; whence the terebratulæ approach nearer to fiſh than the inhabitants of any other ſhell. In the anomiæ which are preſerved in cabinets, there is found only a very ſmall portion of theſe bones, whence they have obtained the improper appellations of *tongue* or *fork*, which indicate only the form of the fragments, and not their uſe.

The ſmall bones of the ears are compoſed of ſeveral pieces, the principal of which is of an oval form; it ſprings from the ſide of the hinge, of which it appears to be a continuation; thence it extends about two-thirds of the breadth of the ſhell, where it is reflected, and reſts againſt the upper part of the fork, to the branches of which it is united by a ſimple ſuperpoſition; a kind of articulation very common among the numerous ſmall bones that compoſe the heads of fiſh. The fork extends from the ſummit a little more than one-third of the breadth of the ſhell: it is formed by a pivot which divides into two long and pointed branches; theſe are remarkably brittle, and ſupport the extremities of the bones of the larger ears. The lamina, which compoſes a ſecond ſet of ears, reſts upon a curved bone, which on one ſide is attached to the inferior internal part of the bone of the larger ears, and on the other reaches to the ſide of the mouth of the animal, where it is united to another flat little bone, which is applied to a ſimilar bone on the other ſide. Theſe laſt little bones are exactly below the membrane which forms the mouth. All theſe bones are flat, very brittle, and ſurrounded with fibres and membranes. By their articulations the ears are enabled to move; they alſo ſupport the body of the animal, which touches neither of the ſhells, but remains between them as upon treſſels. The ſpace between the branches of the bones of the ears is filled up with a tranſparent firm membrane; at the baſe of the fork is a ſimilar one, and a perpendicular partition dividing the ſpace occupied by the body of the animal from the reſt of the ſhell. There are two orifices in this membrane communicating with the ſpace between the two lobes of the manteau, and which ſerves as a trachea; for we have remarked, in the deſcription of the manteau, that the two lobes are entirely ſeparated from each other, and therefore do not form a real trachea.

From this deſcription, it follows that the anomia ought to be ſeparated from the genus oyſter, ſince it has a toothed hinge, ſeveral ligaments, and an interior organization wholly different; neither ought it to be confounded with the cockle, the ſhells of which are both equal, and are deſtitute of any ſenſible perioſteum, without reckoning other differences. It has ſtill leſs analogy with the other bivalves, and therefore ought to conſtitute a peculiar genus; the ſpecies of which, both foſſil and living, are very numerous.

See Plate XLIII. where fig. 1. is a front view of a terebratula of middle ſize. Fig. 2. is a view of the internal ſtructure.—AA, laminæ of the ſuperior ears—BB, laminæ of the inferior—C, the ſtomach—D, the anus—E E, the manteau—F, the œſophagus.

TERNAI, the name given by Perouſe to a very fine

fine bay which he discovered on the coast of Tartary, in Lat. 45° 13′ North, and in Long. 135° 9′ East from Paris. The bottom is sandy, and diminishes gradually to six fathoms within a cable's length of the shore. The tide rises five feet; it is high water at 8h 15m at full and change; and the flux and reflux do not alter the direction of the current at half a league from the shore.

"Five small creeks (says La Perouse), similar to the sides of a regular polygon, form the outline of this roadstead; these are separated from each other by hills, which are covered to the summit with trees. Never did France, in the freshest spring, offer gradations of colour of so varied and strong a green; and though we had not seen, since we began to run along the coast, either a single fire or canoe, we could not imagine that a country so near to China, and which appeared so fertile, should be entirely uninhabited. Before our boats had landed, our glasses were turned towards the shore, but we saw only bears and stags, which passed very quietly along the sea side. The same plants which grow in our climates carpeted the whole soil, but they were stronger, and of a deeper green; the greater part were in flower. Roses, red and yellow lilies, lilies of the valley, and all our meadow flowers in general, were met with at every step. Pine trees covered the tops of the mountains; oaks began only half way down, and diminished in strength and size in proportion as they came nearer the sea; the banks of the rivers and rivulets were bordered with willow, birch, and maple trees, and on the skirts of the forests we saw apple and medlar trees in flower, with clumps of hazle nut trees, the fruit of which already made its appearance. Our surprise was redoubled, when we reflected on the population which overburdens the extensive empire of China, so that the laws do not punish fathers barbarous enough to drown and destroy their children, and that this people, whose polity is so highly boasted of, dares not extend itself beyond its wall, to draw its subsistence from a land, the vegetation of which it would be necessary rather to check than to encourage. At every step after we had landed, we perceived traces of men by the destruction they had made; several trees, cut with sharp-edged instruments; the remains of ravages by fire were to be seen in several places, and we observed some sheds, which had been erected by hunters in a corner of the woods. We also found some small baskets, made of the bark of birch trees, sewed with thread, and similar to those of the Canadian Indians; rackets for walking on the snow; in a word, every thing induced us to think that the Tartars approach the borders of the sea in the season for hunting and fishing; that they assemble in colonies at that period along the rivers; and that the bulk of the nation live in the interior of the country on a soil perhaps better calculated for the multiplication of their immense flocks and herds."

Our navigators caught in the bay vast quantities of fine fish, such as cod, harp-fish, trout, salmon, herrings, and plaice; but though game was plenty on shore, they had no success in hunting. The meadows, so delightful to the sight, could scarce be crossed; the thick grass was three or four feet high, so that they found themselves in a manner buried in it, and they were under the perpetual dread of being bitten by serpents, of which they saw a great number on the banks of the rivulets. They found, however, immense quantities of small onions, sorrel, and celery; which, together with the fresh fish, served as antidotes against the scurvy.

TERRE-PLEIN, or TERRE-PLAIN, in fortification, the top, platform, or horizontal surface of the rampart, upon which the cannon are placed, and where the defenders perform their office. It is so called because it lies level, having only a little slope outwardly to counteract the recoil of the cannon. Its breadth is from 24 to 30 feet; being terminated by the parapet on the outer side, and inwardly by the inner talus.

TERRELLA, or little earth, is a magnet turned of a spherical figure, and placed so as that its poles, equator, &c. do exactly correspond with those of the world. It was so first called by Gilbert, as being a just representation of the great magnetic globe we inhabit. Such a terrella, it was supposed, if nicely poised, and hung in a meridian like a globe, would be turned round like the earth in 24 hours by the magnetic particles pervaiding it; but experience has shewn that this is a mistake.

TETRAEDRON, or TETRAHEDRON, in geometry, is one of the five Platonic or regular bodies or solids, comprehended under four equilateral and equal triangles. Or it is a triangular pyramid of four equal and equilateral faces.

TETRAGON, in geometry, a quadrangle, or a figure having four angles. Such as a square, a parallelogram, a rhombus, and a trapezium. It sometimes also means peculiarly a square.

TETRAGON, in astrology, denotes an aspect of two planets with regard to the earth, when they are distant from each other a fourth part of a circle, or 90 degrees. The tetragon is expressed by the character □, and is otherwise called a square or quartile aspect.

THEBES, in Egypt. Having in the *Encyclopædia* given Mr Bruce's account of this ancient city, which represents it as having been a paltry place, so contrary to the description of Homer, justice to the father of poetry requires that we here notice what has been said of it by a subsequent traveller, who remained three days among its ruins. According to Mr Browne, "the massy and magnificent forms of the ruins that remain of ancient Thebes, the capital of Egypt, the city of Jove, the city with 100 gates, must inspire every intelligent spectator with awe and admiration. Diffused on both sides of the Nile, their extent confirms the classical observations, and Homer's animated description rushes into the memory:

'Egyptian Thebes, in whose palaces vast wealth is stored; from each of whose hundred gates issue two hundred warriors, with their horses and chariots.'

"These venerable ruins, probably the most ancient in the world, extend for about three leagues in length along the Nile. East and west they reach to the mountains, a breadth of about two leagues and a half. The river is here about three hundred yards broad. The circumference of the ancient city must therefore have been about twenty-seven miles.

"In sailing up the Nile, the first village you come to within the precincts is Kourna, on the west, where there are few houses, the people living mostly in the caverns. Next is Abuhadjadj, a village, and Karnac, a small district, both on the east. Far the largest portion of the city ftood on the eaftern fide of the river. On the fouth-weft Medinet-Abu marks the extremity of the ruins; for Arment, which is about two leagues to the fouth, cannot be confidered as a part.

"In defcribing the ruins, we fhall begin with the moft confiderable, which are on the eaft of the Nile. The chief is the Great Temple, an oblong fquare building of vaft extent, with a double colonnade, one at each extremity. The mafly columns and walls are covered with hieroglyphics; a labour truly ftupendous. 1. The Great Temple ftands in the diftrict called *Karnac*. 2. Next in importance is the temple at *Abuhadjadj*. 3. Numerous ruins, avenues marked with remains of fphinxes, &c. On the weft fide of the Nile appear, 1. Two coloffal figures, apparently of a man and woman, formed of a calcareous ftone like the reft of the ruins. 2. Remains of a large temple, with caverns excavated in the rock. 3. The magnificent edifice ftyled the *palace of Memnon*. Some of the columns are about forty feet high, and about nine and a half in diameter. The columns, and walls are covered with hieroglyphics. This ftands at *Kourna*. 4. Behind the palace is the paffage ftyled *Bibân-el-Moluk*, leading up the mountain. At the extremity of this paffage, in the fides of the rock, are the celebrated caverns known as the fepulchres of the ancient kings."

Though Mr Browne agrees with Pococke and Bruce, that the paffage in Homer refers not to the gates of the city, he is yet of opinion, contrary to them, that Thebes had been a walled town. He fays, indeed, that fome faint remains of its furrounding wall are vifible at this day; and he thinks that he difcovered the ruins of three of its gates, though he does not affirm this with abfolute confidence.

THEODOSIUS, a celebrated mathematician, flourifhed in the times of Cicero and Pompey; but the time and place of his death are unknown. This Theodofius the Tripolite, as mentioned by Suidas, is probably the fame with Theodofius, the philofopher of Bythinia, who, Strabo fays, excelled in the mathematical fciences, as alfo his fons; for the fame perfon might have travelled from the one of thofe places to the other, and fpent part of his life in each of them; like as Hipparchus was called by Strabo the Bythinian, but by Ptolemy and others the Rhodian.

Biog. Dict.

Theodofius chiefly cultivated that part of geometry which relates to the doctrine of the fphere, concerning which he publifhed three books. The firft of thefe contains 22 propofitions; the fecond, 23; and the third, 14; all demonftrated in the pure geometrical manner of the ancients. Ptolemy made great ufe of thefe propofitions, as well as all fucceeding writers. Thefe books were tranflated by the Arabians, out of the original Greek, into their own language. From the Arabic the work was again tranflated into Latin, and printed at Venice. But the Arabic verfion being very defective, a more complete edition was publifhed, in Greek and Latin, at Paris 1558, by John Pena, Regius Profeffor of aftronomy. And Vitello acquired reputation by tranflating Theodofius into Latin. This author's works were alfo commented on and illuftrated by Clavius, Heleganius, and Guarinus, and laftly by De Chales, in his Curfus Mathematicus. But that edition of Theodofius's Spherics, which is now moft in ufe, was tranflated and publifhed by our countryman the learned Dr Barrow, in the year 1675, illuftrated and demoftrated in a new and concife method. By this author's account, Theodofius appears, not only to be a great mafter in this more difficult part of geometry, but the firft confiderable author of antiquity who has written on that fubject.

Theodofius, too, wrote concerning the Celeftial Houfes; alfo of Days and Nights; copies of which, in Greek, were in the King's library at Paris. Of which there was a Latin edition, publifhed by Peter Dafypody, in the year 1572.

THEON, of Alexandria, a celebrated Greek philofopher and mathematician, who flourifhed in the 4th century, about the year 380, in the time of Theodofius the Great; but the time and manner of his death are unknown. His genius and difpofition for the ftudy of philofophy were very early improved by clofe application to all its branches; fo that he acquired fuch a proficiency in the fcience as to render his name venerable in hiftory, and to procure him the honour of being prefident of the famous Alexandrian fchool. One of his pupils was the admirable Hypatia, his daughter, who fucceeded him in the prefidency of the fchool; a truft which, like himfelf, fhe difcharged with the greateft honour and ufefulnefs. See her life, *Encycl.*

The ftudy of Nature led Theon to many juft conceptions concerning God, and to many ufeful reflections in the fcience of moral philofophy. Hence, it is faid, he wrote with great accuracy on Divine Providence. And he feems to have made it his ftanding rule, to judge the truth of certain principles, or fentiments, from their natural or neceffary tendency. Thus, he fays, that a full perfuafion that the Deity fees every thing we do, is the ftrongeft incentive to virtue; for he infifts, that the moft profligate have power to refrain their hands, and hold their tongues, when they think they are obferved, or overheard, by fome perfon whom they fear or refpect. With how much more reafon then, fays he, fhould the apprehenfion and belief, that God fees all things, reftrain men from fin, and conftantly excite them to their duty? He alfo reprefents this belief concerning the Deity as productive of the greateft pleafure imaginable, efpecially to the virtuous, who might depend with greater confidence on the favour and protection of Providence. For this reafon, he recommends nothing fo much as meditation on the prefence of God: and he recommended it to the civil magiftrate as a reftraint on fuch as were profane and wicked, to have the following infcription written, in large characters, at the corner of every ftreet—GOD SEES THEE, O SINNER.

Theon wrote notes and commentaries on fome of the ancient mathematicians. He compofed alfo a book, intitled *Progymnafmata*, a rhetorical work, written with great judgment and elegance; in which he criticifed on the writings of fome illuftrious orators and hiftorians; pointing out, with great propriety and judgment, their beauties and imperfections; and laying down proper rules for propriety of ftyle. He recommends concifenefs of expreffion, and perfpicuity, as the principal ornaments. This book was printed at Bafle in the year 1541; but the beft edition is that of Leyden, in 1626, in 8vo.

THEOPHILANTHROPISTS, a fect of deifts, who, in September 1796, publifhed at Paris a fort of catechifm or directory for focial worfhip, under the title

Theophilanthropists.

title of *Manuel des Theanthrophiles*. This religious breviary found favour; the congregation became numerous; and in the second edition of their manuel they assumed the less harsh denomination of *Theophilanthropes, i.e.* lovers of God and man. A book of hymns, a liturgy for every decade of the French year, and an homiletical selection of moral lessons, are announced, or published, by their unknown synod. Thus they possess a system of pious services adapted to all occasions, which some one of the individuals who attend reads aloud; for they object to the employment of a regular lecturer, in consequence of their hostility to priests.—This novel sect was countenanced by Lareveillere Lepaux, one of the Directory, and, soon after its formation, opened temples of its own in Dijon, and in other provincial towns. They had declamations, in the spirit of sermons, which abounded with such phrases as *l'eternal geometre*, and the like, and which have long since been familiar to those who frequent the lodges of free masonry. Whether the sect now exists, or fell at the last revolution which annihilated the directory, we have not learned; but a translation of its *Manuel* into English, for the use, we suppose, of our Jacobins, was made so early as the year 1797. From this contemptible performance, we learn that the creed of the Theophilanthropists is comprised in the four following propositions:

The Theophilanthropists believe in the existence of God, and the immortality of the soul.

The spectacle of the universe attests the existence of the First Being.

The faculty which we possess of thinking, assures us that we have, within ourselves, a principle which is superior to matter, and which survives the dissolution of the body.

The existence of God, and the immortality of the soul, do not need long demonstrations; they are sentimental truths, which every one may find written in his heart, if he consult it with sincerity.

Thus a sort of religious instinct is set up as the sole foundation of piety, which every one has as much right to disavow as another to assert; and the obligations of which, therefore, can in no way be shewn to be incumbent on those to whom this novel illumination is not vouchsafed. Society, under such a system, gains no means of influencing the conduct of refractory members.

The morality of the Theophilanthropists is founded on one single precept: *Worship God, cherish your kind, render yourselves useful to your country!*

Among the duties comprehended under the denomination of cherishing our kind, we find that of *not lending for usury*: the others are chiefly extracted from the gospels, and do not interfere with the province of the civil magistrate. The question of monogamy is not discussed.

Among the duties to our country are placed those of fighting in its defence, and of paying the taxes. It was certainly prudent in the statesman to slide these duties into the catalogne of his established maxims of morality; and he ran thereby little risk of provoking heretical animadversions on his creed in France.

The following inscriptions are ordered to be placed above the altars in the several temples or synagogues of the Theophilanthropists; but for what reason altars are admitted into such synagogues we are not informed:

First inscription, "We believe in the Existence of God, in the immortality of the soul"

Second inscription, "Worship God, cherish your kind, render yourselves useful to the country."

Third inscription, "Good is every thing which tends to the preservation or the perfection of man.—Evil is every thing which tends to destroy or to deteriorate him."

Fourth inscription, "Children, honour your fathers and mothers. Obey them with affection. Comfort their old age.—Fathers and mothers, instruct your children."

Fifth inscription, "Wives, regard in your husbands the chiefs of your houses.—Husbands, love your wives, and render yourselves reciprocally happy."

This pentalogue is chiefly objectionable on account of the vague drift of the fifth commandment: the whole has too general a turn for obvious practical application. The introduction of ceremonies, of sculpture, of painting, and of engraving, is forbidden. If poetry and music may concur to render the worship impressive, why not the other fine arts? The fine arts have never illustrated a country which excluded them from the public temples. Are they to be extinguished in France by Theophilanthropic iconoclasts?

At p. 28. of the Manuel, this surprising maxim occurs: *Avoid innovations!* A sect fifteen months old grown as testy as the church of Rome! They acknowledge, that perhaps better inscriptions may be found; yet they forbid the exchange. They prefer *mumpsimus* to the *sumpsimus* of genuine Christianity!

Theophilus.

THEOPHILUS, a writer and bishop of the primitive church, was educated a Heathen, and afterwards converted to Christianity. Some have imagined that he is the person to whom St Luke dedicates the Acts of the Apostles: but they are grossly mistaken; for this Theophilus was so far from being contemporary with St Luke and the apostles, that he was not ordained bishop of Antioch till *anno* 170; and he governed this church twelve or thirteen years. He was a vigorous opposer of certain heretics of his time, and composed a great number of works; all of which are lost, except three books to Autolycus, a learned Heathen of his acquaintance, who had undertaken to vindicate his own religion against that of the Christians. The first book is properly a discourse between him and Autolycus, in answer to what this Heathen had said against Christianity. The second is to convince him of the falsehood of his own, and the truth of the Christian religion. In the third, after having proved that the writings of the Heathens are full of absurdities and contradictions, he vindicates the doctrine and the lives of the Christians from those false and scandalous imputations which were then brought against them. Lastly, at the end of his work, he adds an historical chronology from the beginning of the world to his own time, to prove that the history of Moses is at once the most ancient and the truest; and it appears from this little epitome, how well this author was acquainted with profane history. These three books are filled with a great variety of curious disquisitions concerning the opinions of the poets and philosophers, and there are but few things in them relating immediately to the doctrines of the Christian religion. Not that Theophilus was ignorant of these doctrines, but, having composed his works for the *Biog. Dict.*

Therapeutæ.

the converſion of a Pagan, he inſiſted rather on the external evidence or proofs from without, as better adapted, in his opinion, to the purpoſe. His ſtyle is elegant, and the turn of his thoughts very agreeable; and this little ſpecimen is ſufficient to ſhew that he was indeed a very eloquent man.

The piece is intitled, in the Greek manuſcripts, "The books of Theophilus to Autolycus, concerning the Faith of the Chriſtians, againſt the malicious detractors of their religion." They were publiſhed with a Latin verſion, by Conradus Geſner, at Zurich, in 1546. They were afterwards ſubjoined to Juſtin Martyr's works, printed at Paris in 1615 and 1636; then publiſhed at Oxford, 1684, in 12mo, under the inſpection of Dr Fell; and, laſtly, by Jo. Chriſt. Wolfius, at Hamburgh, 1723, in 8vo.

It is remarkable, that this patriarch of Antioch was the firſt who applied the term *Trinity* to expreſs the Three Perſons in the Godhead.

THERAPEUTÆ, ſo called from the extraordinary purity of their religious worſhip, were a Jewiſh ſect, who, with a kind of religious phrenzy, placed their whole felicity in the contemplation of the Divine nature. Detaching themſelves wholly from ſecular affairs, they transferred their property to their relations or friends, and withdrew into ſolitary places, where they devoted themſelves to a holy life. The principal ſociety of this kind was formed near Alexandria, where they lived, not far from each other, in ſeparate cottages, each of which had its own ſacred apartment, to which the inhabitant retired for the purpoſes of devotion. After their morning prayers, they ſpent the day in ſtudying the law and the prophets, endeavouring, by the help of the commentaries of their anceſtors, to diſcover ſome allegorical meaning in every part. Beſides this, they entertained themſelves with compoſing ſacred hymns in various kinds of metre. Six days of the week were, in this manner, paſſed in ſolitude. On the ſeventh day they met, clothed in a decent habit, in a public aſſembly; where, taking their places according to their age, they ſat, with the right hand between the breaſt and the chin, and the left at the ſide. Then ſome one of the elders, ſtepping forth into the middle of the aſſembly, diſcourſed, with a grave countenance and a calm tone of voice, on the doctrines of the ſect; the audience, in the mean time, remaining in perfect ſilence, and occaſionally expreſſing their attention and approbation by a nod. The chapel where they met was divided into two apartments; one for the men, the other for the women. So ſtrict a regard was paid to ſilence in theſe aſſemblies, that no one was permitted to whiſper, or even to breathe aloud; but when the diſcourſe was finiſhed, if the queſtion which had been propoſed for ſolution had been treated to the ſatisfaction of the audience, they expreſſed their approbation by a murmur of applauſe. Then the ſpeaker, riſing, ſung a hymn of praiſe to God, in the laſt verſe of which the whole aſſembly joined. On great feſtivals, the meeting was cloſed with a vigil, in which ſacred muſic was performed, accompanied with ſolemn dancing: and theſe vigils were continued till morning, when the aſſembly, after a morning prayer, in which their faces were directed towards the riſing ſun, was broken up. So abſtemious were theſe aſcetics, that they commonly ate nothing before the ſetting ſun, and often faſted two or three days. They abſtained from wine, and their ordinary food was bread and herbs.

Thermometric.

Much diſpute has ariſen among the learned concerning this ſect. Some have imagined them to have been Judaizing Gentiles; but Philo ſuppoſes them to be Jews, by ſpeaking of them as a branch of the ſect of Eſſenes, and expreſsly claſſes them among the followers of Moſes. Others have maintained, that the Therapeutæ were an Alexandrian ſect of Jewiſh converts to the Chriſtian faith, who devoted themſelves to a monaſtic life. But this is impoſſible; for Philo, who wrote before Chriſtianity appeared in Egypt, ſpeaks of this as an eſtabliſhed ſect. From comparing Philo's account of this ſect with the ſtate of philoſophy in the country where it flouriſhed, we conclude that the Therapeutæ were a body of Jewiſh fanatics, who ſuffered themſelves to be drawn aſide from the ſimplicity of their ancient religion by the example of the Egyptians and Pythagoreans. How long this ſect continued is uncertain; but it is not improbable that, after the appearance of Chriſtianity in Egypt, it ſoon became extinct.

THERMOMETRIC SPECTRUM, is a name given to the ſpace in which a thermometer may be placed, ſo that it ſhall be affected by the ſun's rays refracted by a priſm. It is, in part, the ſame with the PRISMATIC SPECTRUM, which exhibits the different colours produced by the ſolar light.

The philoſophical inſtrument now called a *thermometer*, was firſt named THERMOSCOPE; and was prized by the naturaliſt, becauſe it gave him indications of the preſence and agency of fire in many caſes where our ſenſation of warmth or heat was unable to diſcover it. It was not long before it was obſerved that it alſo affords us meaſures of the changes which take place either in the quantity or the activity of the cauſe of heat, and of many other important phenomena uſually accompanied by heat They were then called *thermometers*. But in both of theſe offices, it is ſtill a doubt whether it indicates and meaſures any real ſubſtance, a being *ſui generis*, to which we may give the name *fire*, *phlogiſton*, *caloric*, *heat*, or any other; or only indicates and meaſures certain ſtates or conditions, in which all bodies may be found, without the addition or abſtraction of any material ſubſtance.

We think that this queſtion has a greater chance now of being decided than in any former time, in conſequence of a recent and very important diſcovery made by that unwearied obſerver of the works of God, the celebrated Dr Herſchel. Being greatly incommoded when looking at the ſun, by the great heats produced in the eye-pieces of his teleſcopes, he thought that the laws of refraction enabled him to diminiſh them by a proper conſtruction of his eye-pieces. He began his attempts like a philoſopher, by examining the heat produced in the various parts of the priſmatic ſpectrum. Comparing the gradation of heat with that of illumination, he found that they did not, by any means, follow the ſame law. The illumination increaſed gradually from the violent end of the ſpectrum, where it was exceedingly faint, to the boundary of the green and yellow, where it was the moſt remarkable; and after this it decreaſed as the illuminated object approached the red extremity of the ſpectrum. But the calorific power of the refracted light increaſed all the way from the extreme violet to the extreme red; and its laſt augmentations

Thermometric.

tations were confiderable, and therefore unlike the ufual approaches of a quantity to its maximum ftate. This made him think of placing the thermometer a little way beyond the extremity of the vifible fpectrum. To his great aftonifhment, he found that the thermometer was more affected there than in the hotteft part of the *illuminated* fpectrum. Expofing the thermometer at various diftances beyond the extreme red, but in the plane of refraction, he found that it was moft ftrongly affected when placed beyond that extremity, about one-fifth of the whole length of the fpectrum; from thence the calorific influence of the fun gradually diminifhed, but was ftill very confiderable, at a diftance from the extreme red equal to three-fifths of the length of the luminous fpectrum. Thefe firft fuggefted modes of trial appeared to Dr Herfchel to be too rude to intitle him to fay that the warming influence did not extend ftill farther. Indeed the inftrument fcarcely performed the part of a thermometer, but merely that of an indicator of heat, or a thermofcope.

Here is a very new, and wonderful, and important, piece of information. We apprehend that all the philofophers of Europe, as well as the unlearned of all nations, believe that the *warming* influence of the fun, and of other luminous bodies, is conjoined with their power of *illumination*. Moft of the philofophers admitted the emiffion of a matter called *light*, projected from the fhining body, and moving with aftonifhing velocity, in thofe lines which the mathematicians called *rays*, becaufe they diverged from the fhining point, as the *radii* or fpokes of a wheel diverge from the nave. This notion feems to be the fimple fuggeftion of Nature; and it alfo feems to be the opinion entertained by Sir Ifaac Newton. His demonftration of the laws of reflection and refraction proceeds on this fuppofition alone, and the particles of light are held by him to be affected by accelerating and deflecting forces, in the fame way as a ftone thrown from the hand is affected by gravity. Huyghens, indeed, Dr Hooke, and Euler, imagined that vifion and illumination were effected in the fame way that hearing, and refonance, and echo, are effected—that there is no matter projected from the fhining body; but that we are furrounded by an elaftic fluid, which is thrown into vibrations by certain tremors of the vifible object—and that thofe vibrations of this fluid affect our eye in the fame way as the undulation of elaftic air, produced by the tremors of a ftring or a bell, affect our ear. According to thefe philofophers, a ray of vifion is merely the line which paffes through all thefe undulations at right angles.

Thefe two opinions ftill divide the mathematical philofophers of Europe; but the majority, and particularly the moft eminent for mathematical and mechanical fcience, are (with the exception of Huyghens and Euler) on the fide of the vulgar. This opinion has been greatly ftrengthened of late years by the difcoveries in chemiftry. The influence of light on the growth of plants, the total want of aromatic oils in fuch as grow in the dark, and their formation and appearance in the very fame plant, along with the green colour, as foon as the plant is placed in the light (even that of open day without funfhine, or in the light of a candle), is a ftrong indication of fome fubftance being obtained from the light, abforbed by the plant, and combined with its other ingredients. The fame conclufion is drawn from the effects of the fun's light on vegetable colours, on the nitric and nitrous acids, on manganefe, on the calces or oxides of metals, and numberlefs other inftances, which all concur in rendering it almoft unqueftionable that the fun's rays, and thofe of other fhining bodies, may be, and daily are, combined with the other fubftances of which bodies are compofed, and may be again feparated from them. And, fhould any doubts remain, it would feem that the theory of combuftion, firft conceived and imperfectly publifhed by Dr Hooke in his *Micrography*, p. 103. and in his *Lampus*, p. 1. &c. adopted by Mayow (fee Hooke and Mayow in this *Suppl.*), forgotten, and lately revived and confirmed by Mr Lavoifier, removes them entirely. In the beautiful and well-contrived experiments of the laft gentleman, the light, accompanied by its heat, which had been abforbed in the procefs of growth or other natural operations, re-appeared in their primitive form, and might again be abforbed and made to undergo the fame round of changes.

Scheele, not inferior to Newton in caution, patience, and accuracy, and attentive to every thing that occurred in his experiments, difcovered the feparability of the illuminating and the warming influences of fhining bodies. He remarked, that a plate of glafs, the moft colourlefs and pellucid that can be procured, when fuddenly interpofed between a glowing fire and the face, inftantly cuts off the warming power of the fire, without caufing any fenfible diminution of its brilliancy. He followed this difcovery into many obvious confequences, and found them all fully confirmed by obfervation and experiment. The writer of this article, immediately on hearing of Scheele's experiments, repeated them with complete fuccefs: but he found, that when the glafs plate had acquired the higheft temperature which it could acquire in that fituation, it did not any longer intercept the heat, or at leaft in a very fmall and almoft infenfible degree. It feemed to abforb the heat, till faturated, without abforbing any confiderable portion of the light.

This feparability of heat from light does not feem to have met with the attention it deferved. Dr Scheele's untenable theories on thefe fubjects turned away the attention of the chemifts from this difcovery, and the mathematical philofophers feem not to have heard of it at all. The late Dr Hutton of Edinburgh was more fenfible of its importance; and in his laft endeavours to fupport the falling caufe of phlogifton, makes frequent allufions to it. But in his attempts to explain the curious obfervations of Meffrs Sauffure and Pictet, in which there are unqueftionable appearances of radiated heat, he reafons fo unconfequentially, that few readers proceed farther, fo as to notice feveral obfervations of facts where the illuminating and warming influences are plainly feparated. In all thefe inftances, however, Dr Hutton confiders the invifible rays as light, but not as heat; maintaining that they are invifible, or do not render bodies vifible, only becaufe our eyes are infenfible to their feeble action.

It was referved for Dr Herfchel to put this matter beyond difpute by thefe valuable experiments. For did the invifibility of any of the light beyond the extreme red of the prifmatic fpectrum arife from the infenfibility of our organs, the fpectrum would gradually fade away beyond the red; but it ceafes abruptly. Thefe thoughts could

could not efcape this attentive obferver. He therefore examined more particularly thofe invifible rays, caufing them to be reflected by mirrors, and refracted through lenfes; and, in fhort, he fubjected them to all the fubfequent treatments which Newton applied to the colouring rays. He found them retain their fpecific refrangibilities and reflexibilities with as much uniformity and obftinacy as Newton had obferved in the colour-making rays. They were made to pafs through lenfes while the illuminating rays were intercepted by an opaque body, and the invifible rays were then collected into a focus. They were reflected, both by the anterior and pofterior furfaces of tranfparent bodies. In all thefe trials they retained their power of expanding the liquor of a thermometer, and exciting the fenfation of heat.

Thefe trials were not confined to the folar light or the folar rays: They were alfo made on the emanations from a candle, from an open fire, and from red-hot iron; then they were made with bodies not hot enough to fhine; with the heat of a common ftove, and the heat from iron which was not vifible in the dark. The event was the fame in all; and it was clearly proved that heat, or the caufe of heat, is as fufceptible of radiation as light is; and that this radiation is performed in both according to the fame laws.

We look with impatience for the fubfequent experiments of this celebrated philofopher on this fubject; for we confider them as of the greateft and moft extenfive importance for explaining the operations of Nature. We fee, with indifputable evidence, that there are rays from the fun, and other bodies, which do not illuminate. It does not follow, however, that there are rays which do not warm; for the thermometer was affected in every part of the coloured fpectrum. Dr Herfchel feems to think that the power of affecting the organ of fight depends on the particular degrees of mechanical momentum which are indicated by the different degrees of refrangibility. We confefs that we think it unlikely that fuch a power fhould terminate abruptly. We do not obferve this in analogous phenomena: the evanefcence of our fenfations of found, of mufical pitch, of heat, &c. are all gradual. We think it more likely that illuminating and warming are fpecific effects of different things. We fhould have entertained this opinion independent of all other experience: and we think it ftrongly confirmed by the experiments of Dr Scheele already mentioned. We are difpofed therefore to believe that there are rays which illuminate, but which do not warm; and rays which warm without illuminating. We have experiments in profpect, by which we hope to put this to the teft.

Thefe experiments of Dr Herfchel afford another good argument for the common opinion concerning light, namely, that *it is a matter emitted from the fhining body*, and not merely the undulations of an elaftic medium; for if it were undulation, then, fince there is heat in the yellow light, it would follow that a certain frequency of undulation produces both the fenfation of heat and the fenfation of a yellow colour. In this cafe they fhould be infeparable.

This follows, in the ftricteft manner, from the principles or affumptions adopted by Euler in his mechanical theory of undulations. The chromatic differences in the rays of light are affirmed to arife entirely from the different frequencies of the æthereal undulations; and he endeavours to fhew that thefe differences in frequency produce a difference in refrangibility. It is evident that this reafoning is equally conclufive with refpect to the calorific or heating power of the rays. The light and the heat are both undulations: thefe differ only in frequency; and this frequency is indicated (according to Euler) by the refrangibility. There is a certain frequency therefore which excites the fenfation of yellow. The fame frequency, indicated by the fame refrangibility, produces heat; therefore the frequency which produces this degree of heat alfo produces the fenfation of yellow. We muft not fay that the momentum of the undulation may produce heat, but is infufficient for the production of light, as a ftring may vibrate too feebly for being heard; for we fee, by Dr Herfchel's experiments, that, with a momentum fufficient for making the moft brilliant fpectrum, there are rays (and thofe which have the greateft momentum) which produce heat, and yet are invifible.

It does not follow, from any of Dr Herfchel's experiments, that the rays emitted by iron, which is not hot enough to fhine in a dark room, have *all* the different degrees of refrangibility obferved by him. Perhaps none of them would fall on the chromatic fpectrum. We think, however, that this is not probable. It may be tried by collecting them to a focus by a lenfe, intercepting, however, all thofe which are lefs refrangible than the red-making rays. We truft that the thermometer in the focus will ftill be affected.

This is but a very imperfect account of this important difcovery: but we thought that it would be highly interefting to our readers. The prefs was employed on this very fheet when we received the information from a friend, who had feen Dr Herfchel's Differtation, which will appear in the firft volume publifhed by the Royal Society. We truft that the ingenious author will foon follow it up with the inveftigation of the fubject in all its confequences. 1800.

We hope that he will examine what will refult from mixing fome of the invifible rays with fome of the coloured ones. We know that the yellow and the blue, when mixed, produce the fenfation of green. Perhaps the invifible rays may alfo change the appearance. We do not, however, expect this.

We alfo hope that Dr Herfchel will examine whether the invifible rays of the fun produce any effect on vegetable colours; whether they blacken the calces of filver and bifmuth, luna cornea, and decompofe the nitrous and the oxygenated muriatic acid, &c. &c. We fhould thus get more infight into the nature of caloric and of combuftion. Combuftion may perhaps be reftored to its rank in the phenomena of Nature, and no longer be funk in the general gulph of oxygenation, and thus obliterated from the memory of chemifts. It is perhaps the moft remarkable phenomenon of material Nature; and *fire* and burning will never go out of the language of plain men. Fire, and all its concomitants, have, in all times, been confidered as even the *chief* objects of chemical attention; and an unlearned perfon will ftare, when a chemift tells him that there is no fuch thing, and that what he calls the burning of a piece of coal is only the making it four. He will perhaps fmile; but it will not be a fmile of affent.

It was one darling object of the Revolutionary Committee of Chemifts, affembled at Paris in 1787, to banifh from our minds, *by means of a new language*, all remembrance

remembrance of any thing which we did not derive from the philofophers of France. We think ourfelves in a condition to prove this by letters to this country from the fcene of action; in which the expected victory is fpoken of in terms of exultation, and with fo little reftraint, that the writer forgets that it is Dr Black whom he is informing that *l'air fixe* and *la pauvre phlogiftique* will foon be forgotten; and yet the writer was a gentleman of uncommon modefty and worth, and fincerely attached to Dr Black. We give this as a remarkable inftance of the *efprit de corps*, and of the nature and towering ambition of that nation. From this they have not fwerved; and they hope to gain this fummit of fcientific dominion in the fame way as *the fame philofophers* hope to banifh Chriftianity by means of their new kalendar. It may, however, turn out that both Dr Hooke and Mr Lavoifier are miftaken, when they make the oxygen gas the fole fource of both the light and the heat which accompany combuftion. One of them may perhaps be furnifhed by the body which all, except the new philofophers, call combuftible.

The objections which may be made to the theory of Huyghens and Euler, on the acknowledged principles of mechanics, appear to us unanfwerable. Euler has never attempted to anfwer thofe taken from the different difperfing powers of different fubftances. The objections made to the Newtonian, or vulgar theory of emiffion, are not fuch as imply abfurdity; they are only difficulties. The chief of them, *viz.* the famenefs of velocity in all lights whatever, is of this kind. It is merely an improbability. But the objections to the theory of undulation, deduced from the chemical effects of light, are not lefs ftrong than thofe deduced from mechanical principles. It is quite inconceivable that the undulation of a medium, which pervades all bodies, fhall produce aromatic oils in fome, a green fæcula in others, fhall change fulphuric acid into fulphur, &c. &c. No effects are produced by the undulations of air, or the tremors of elaftic bodies, which have the moft diftant analogy or refemblance to thefe.

That the fun and other fhining bodies emit the matter of light and heat, feems therefore to merit the general reception which it meets with from the philofophers. But even of this clafs there are differences in opinion. Some imagine that light only is emitted, and that the heat which we feel is occafioned by the action of the luminous rays on our atmofphere, or on the ground. Were the fun's calorific rays as denfe at the furface of the fun as his luminous rays are, the heat there muft exceed (fay they) all that we can form any conception of. Yet we fee, that when the nucleus of the fun is laid bare by fome natural operation, which, like a volcanic explofion, throws afide the luminous ocean which covers it to a prodigious depth, the naked parts of this nucleus are black. Therefore the intenfe heat in that place is not able to make it fhining hot, as it does in all our experiments with intenfe heats, giving a dazzling glare. This is thought highly improbable; and it is therefore fuppofed that there is, primitively, no heat in the fun's rays, but that they act on our air, or other terreftrial matter, combining with it, and difengaging heat from it, or producing that particular ftate and condition which we call *heat*.

We think that Dr Herfchel's difcovery militates ftrongly and irrefiftibly againft this opinion; and fhews, that whatever reafon we have for faying that the fun's rays bring light from the fun, we have the fame authority for faying, that they bring heat, fire, caloric, phlogifton, or by whatever other name we choofe to diftinguifh the caufe of warmth, expanfion, liquefaction, ebullition, &c.

We muft either fay that light and heat are not fubftances of a peculiar kind, fufceptible of union with the other ingredients of bodies, but merely a ftate of undulation of an elaftic medium, as found is the undulation of air; or we muft fay that the fun's rays contain light and heat, in a detached ftate, fit for appearing in their fimpleft form, producing illumination and expanfion, and for uniting chemically with other matter. Whichever of thefe opinions we adopt, it is pretty clear that all attempts to difcover a difference in the weight of hot and cold bodies may be given over. In the firft cafe, it is felf-evident; in the fecond, we have abundant evidence, that if light and heat, being gravitating matter, like all other bodies, were added to, or abftracted from bodies, in fufficient quantity to be fenfibly heavy, the rays of the fun, or even the light of a candle, would occafion inftant deftruction by its mere momentum; fince every particle of radiated light and heat moves at the rate of 200,000 miles in a fecond.

This difcovery of Dr Herfchel's adds greatly to the probability of the opinion which we expreffed on another occafion, that the forces or powers of natural fubftances, which are the immediate caufes of the chemical phenomena, are no way different from the mechanical forces which render bodies heavy, coherent, elaftic, expanfive, &c.; in fhort, that they are what we call *accelerating forces*. We deduced this from the fact, that mechanical force can be oppofed to them, fo as to prevent their action in circumftances where it would otherwife certainly take place. Thus by external preffure, we can prevent that union of water and caloric which would convert it into elaftic fteam. We can even difunite them again, when fteam is already produced, by forcibly condenfing it into a fmaller fpace. Now, the refraction and reflection of heat are performed according to the fame precife laws which we obferve in the refraction and reflection of light; and Sir Ifaac Newton has demonftrated that thofe phenomena arife from the action of accelerating forces, whofe direction is perpendicular to the acting furfaces. The matter of heat, therefore, is like other matter in its mechanical properties; and, in the motion of refraction, it is acted on and deflected, juft as a projectile is acted on and deflected by gravity. It continues in motion till its velocity and direction are changed by deflecting forces, exerted by the particles of the tranfparent medium or the reflecting furface. It would take up too much room, but it is a very eafy procefs, to demonftrate that this regular refraction of heat is altogether incompatible with the ufually fuppofed notion of caloric; namely, that it is an expanfive fluid like air, but incomparably more elaftic: from which property very plaufible explanations have been given of the elafticity of gafes, fteams, and fuch like fluids. Every intelligent mechanician will be fenfible, that all this fort of chemical fcience falls to the ground, when it is proved, by exhibition of the fact, that radiated heat is refracted in the fame way with radiated light. We muft look for the explanation of the immenfe explofive force of fulminating filver, gold, &c. in fome

 very

very different principles from those which are now in vogue. We apprehend, too, that the very phenomenon of this refraction gives indication of forces which are sufficiently powerful for this explanation: For when we reflect on the astonishing velocity of the ray of heat; on the minute space along which it is deflected, and consequently the time of this action, minute beyond all imagination; and when we compare these circumstances with the deflection produced by gravity in the motion of a projectile—it is evident that the deflecting force of refraction must exceed the greatest force that we have any knowledge of, in a greater proportion than the weight of Mount Ætna exceeds that of a particle of sand. We would desire Mr de la Place to suspend his hopes of establishing universal fatalism, till he can reconcile these phenomena with his fundamental principle, "*that all forces which are diffused from a single point, necessarily and essentially diminish in the inverse duplicate ratio of the distances.*" Till he can do this, he had better still allow, with Newton, that the selection of the duplicate ratio for the action of gravity (by which alone the solar system can be rendered permanent and orderly) is a mark of wisdom and benevolence. We would advise him to reconcile his mind to this; and perhaps, like the modest and admiring Newton, he may, in good time, find comfort in the thought.

It is also highly worthy of remark, that this refracting force, almost immense, which is so plainly exerted between the particles of bodies and light, when considered as of the same kind with those that produce chemical union, appears abundantly sufficient for explaining some of the most wonderful phenomena of chemistry; such as the prodigious elasticity of steam, of gunpowder, and the still more astonishing explosion of fulminating gold and silver. Some of the phenomena of deflected light are produced by these optical forces acting at distances sufficiently great to admit of measurement; as in the Newtonian observations on the passage of light near the edges of opaque bodies. These deflections enable us to compare the deflecting forces with gravity. The *refracting* force, however, is vastly greater than even this, as may be seen by the greater deflection which is produced by it; and, being exerted along a space incomparably smaller, it must be greater still. Here, then, are forces fully adequate to the phenomena of fulmination. And we would again desire Mr De la Place to remark that, although these exploding forces are irresistible, their action seems to vanish entirely beyond the limits of mathematical contact. This is plain from the fact, that those explosions do not project the fragments to great distances. This is remarkably the case in all the most eminent of them. Common or nitric gunpowder is perhaps the only great exception. This particular circumstance will surely suggest to this eminent analyst the *inverse triplicate* ratio of the distance as more likely to explain the phenomena than his favourite law.

We trust that our readers will not be displeased with this short sketch of Dr Herschel's discovery, and the few reflections which it naturally suggested to our minds. We shall not be greatly surprised, although it should produce a sort of counter-revolution in chemical science, in consequence of new conceptions which it may give us of the union of bodies with light and heat. The phenomena of the vegetable and animal economy shew that they are susceptible of combination with other substances besides the basis of vital air. Whatever changes this may produce in the great revolution which has already taken place in chemical science, they will (in our opinion) be favourable to true philosophy; because Dr Herschel's discovery co-operates with other arguments of sound mathematical reasoning, to overturn that principle on which De la Place hopes to found his atheistical doctrine of fate and necessity. It contributes therefore to restore to the face of Nature that smiling feature of providential WISDOM which Newton had the honour of exhibiting to the view of rational men. The sun is the source of light and genial warmth to a vast system, which is held together, in almost eternal order and beauty, by a law of attraction selected by Infinite Wisdom, as the only one adequate to this magnificent purpose.

THEVENOT (Melchisedec), librarian to the king of France, and a celebrated writer of travels, was born at Paris in 1621, and had scarcely gone through his academical studies, when he discovered a strong passion for visiting foreign countries. At first he saw only part of Europe; but then he took great care to procure very particular informations and memoirs from those who had travelled over other parts of the globe, and out of those composed his "Voyages and Travels."—He laid down, among other things, some rules, together with the invention of an instrument, for the better finding out of the longitude, and the declination of the needle; and some have thought that these are the best things in his works, since travels, related at second-hand, can never be thought of any great authority or moment; not but Thevenot travelled enough to relate some things upon his own knowledge. Another passion in him, equally strong with that for travelling, was to collect scarce books in all sciences, especially in philosophy, mathematics, and history; and in this he may be said to have spent his whole life. When he had the care of the King's library, though it was one of the best furnished in Europe, he found 2000 volumes wanting in it which he had in his own. Besides printed books, he bought a great many manuscripts in French, English, Spanish, Italian, Latin, Greek, Hebrew, Syriac, Arabic, Turkish, and Persic. The marbles presented to him by Mr Nointel, at his return from his embassy to Constantinople, upon which there are bas-reliefs and inscriptions almost 2000 years old, may be reckoned among the curiosities of his library. He spent most of his time among his books, without aiming at any post of figure or profit: he had, however, two honourable employments; for he assisted at a conclave held after the death of Pope Innocent X. and was the French king's envoy at Genoa. He was attacked with what is called a slow fever in 1692, and died October the same year, at the age of 71. According to the account given, he managed himself very improperly in this illness; for he diminished his strength by abstinence, while he should have increased it with hearty food and generous wines, which were yet the more necessary on account of his great age.—Thevenot's Travels into the Levant, &c. were published in English in the year 1687, folio; they had been published in French at Paris 1663, folio. He wrote also "L'Art de Nager," the Art of Swimming, 12mo, 1696.

THOMAS (Christian). was born at Leipsic 1655, and

Thomas Thomas, Thornton.

and was well educated, first under his father, and afterwards in the Leipsic university. At first he acquiesced in the established doctrines of the schools; but upon reading Puffendorf's "Apology for rejecting the Scholastic Principles of Morals and Law," light suddenly burst upon his mind, and he determined to renounce all implicit deference to ancient dogmas. He read lectures upon the subject of Natural Law, first from the text of Grotius, and afterwards from that of Puffendorf, freely exercising his own judgment, and, where he saw reason, advancing new opinions. Whilst his father was living, paternal prudence and moderation restrained the natural vehemence and acrimony of the young man's temper, which was too apt to break out, even in his public lectures. But when he was left to himself, the boldness with which he advanced unpopular tenets, and the severity with which he dealt out his satirical censures, soon brought upon him the violent resentment of theologians and professors.

An "Introduction to Puffendorf," which Thomas published in the year 1687, wherein he deduced the obligation of morality from natural principles, occasioned great offence. The following year he became still more unpopular, by opening a monthly literary journal, which he intitled "Free Thoughts, or Monthly Dialogues on various Books, chiefly new;" in which he attacked many of his contemporaries with great severity. The raillery of this satirical work was too provoking to be endured: complaints were lodged before the ecclesiastical court of Dresden; the bookseller was called upon to give up the author; and it was only through the interest of the Mareschal that Thomas escaped punishment. The title of the work was now changed; but its spirit remained. A humorous and satirical life of Aristotle, and several other sarcastic papers, kept alive the flame of resentment, till at length it again burst forth, on a charge brought against him before the same court by the clergy of Leipsic, for contempt of religion: but he defended himself with such ability, that none of his adversaries chose to reply, and the matter was dropped.

A satirical review, which he wrote, of a treatise "On the Divine Right of Kings," published by a Danish divine; "A Defence of the Sect of the Pietists," and other eccentric and satirical publications, at last inflamed the resentment of the clergy against Thomas to such a degree, that he was threatened with imprisonment. To escape the storm which thickened about him, he entreated permission from the Elector of Brandeburg, in whose court he had several friends, that he might read private lectures in the city of Hall. This indulgence being obtained, Thomas became a voluntary exile from Leipsic. After a short interval, he was appointed public professor of jurisprudence, first in Berlin, and afterwards at Hall. In these situations, he found himself at full liberty to indulge his satirical humour, and to engage in the controversies of the times: and as long as he lived, he continued to make use of this liberty in a manner which subjected him to much odium. At the same time, he persevered in his endeavours to correct and subdue the prejudices of mankind, and to improve the state of philosophy. He died at Hall in the year 1728.

Besides the satirical journal already mentioned, Thomas wrote several treatises on logic, morals, and jurisprudence; in which he advanced many dogmas contrary to received opinions. In his writings on Physics, he leaves the ground of experiment and rational investigation, and appears among the mystics. His later pieces are in many particulars inconsistent with the former.—His principal philosophical works are, "An Introduction to Aulic Philosophy, or Outlines of the Art of Thinking and Reasoning;" "Introduction to Rational Philosophy;" "A Logical Praxis;" "Introduction to Moral Philosophy;" "A Cure for Irregular Passions, and the Doctrine of Self-Knowledge;" "The new Art of discovering the secret Thoughts of Men;" "Divine Jurisprudence;" "Foundations of the Law of Nature and Nations;" "Dissertation on the Crime of Magic;" "Essay on the Nature and Essence of Spirit, or Principles of Natural and Moral Science;" "History of Wisdom and Folly."

From the specimen given by Dr Enfield of his more peculiar tenets (for we have read none of his books), Thomas appears to have been a man of wonderful inconsistency in his opinions; teaching on one subject rational piety and true science, and on another absurdity and atheism. "No other rule (he says) is necessary in reasoning, than that of following the natural order of investigation; beginning with those things which are best known, and proceeding, by easy steps, to those which are more difficult." This is perfectly consistent with the foundation of the Baconian logic; and is indeed the only foundation upon which a system of science can possibly be built. Yet could the man, who professes to proceed from a principle so well established, gravely advance, as conclusions of science, the following absurdities: "Perception is a passive affection, produced by some external object, either in the intellectual sense, or in the inclination of the will. God is not perceived by the intellectual sense, but by the inclination of the will: for creatures affect the brain; but God, the heart. All creatures are in God: nothing is exterior to him. Creation is extension produced from nothing by the divine power. Creatures are of two kinds, passive and active; the former is matter, the latter spirit. Matter is dark and cold, and capable of being acted upon by spirit, which is light, warm, and active. Spirit may subsist without matter, but desires a union with it. All bodies consist of matter and spirit, and have therefore some kind of life. Spirit attracts spirit, and thus sensibly operates upon matter united to spirit. This attraction in man is called *love;* in other bodies, *sympathy*. A finite spirit may be considered as a limited sphere, in which rays, luminous, warm, and active, flow from a centre. Spirit is the region of the body to which it is united. The region of finite spirits is God. The human soul is a ray from the divine nature; whence it desires union with God, who is love. Since the essence of spirit consists in action, and of body in passion, spirit may exist without thought: of this kind are light, ether, and other active principles in nature." Fortunately, this jargon is as unintelligible as the categories of Kant, and the blasphemies of Spinoza; for an account of which, the reader is referred to *Critical Philosophy* in this *Suppl.* and to Spinoza in the *Encycl.*

THORNTON (Bonnel), a modern poet, the intimate friend of Lloyd and Colman, and justly classed with them in point of talents, was born in Maidenlane, London, in the year 1724. He was the son of *Biographical Dictionary.*

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Thornton.

an apothecary; and being educated at Weſtminſter ſchool, was elected to Chriſt-Church, Oxford, in the year 1743. He was thus eight years ſenior to Colman, who was elected off in 1751. The firſt publication in which he was concerned was, "The Student, or Oxford and Cambridge Miſcellany," which appeared in monthly numbers; and was collected in two volumes 8vo, in 1748. Smart was the chief conductor of the work; but Thornton, and other wits of both univerſities, aſſiſted in it. He took his degree of maſter of arts in 1750; and as his father wiſhed him to make phyſic his profeſſion, he took the degree of bachelor of that faculty in 1754. In the ſame year he undertook the periodical paper called *The Connoiſſeur*, in conjunction with Colman, which they continued weekly to the 30th of September 1756. In the concluding paper, the different ages and purſuits of the two authors are thus jocularly pointed out, in the deſcription of the double author, Mr Town. "Mr Town is a fair, black, middle-ſized, very ſhort man. He wears his own hair and a periwig. He is about thirty years of age (literally thirty-two), and not more than four-and twenty. He is a ſtudent of the law and a bachelor of phyſic. He was bred at the univerſity of Oxford, where, having taken no leſs than three degrees, he looks down on many learned profeſſors as his inferiors: yet, having been there but little longer than to take the firſt degree of bachelor of arts, it has more than once happened that the cenſor-general of all England has been reprimanded by the cenſor of his college, for neglecting to furniſh the uſual eſſay, or, in the collegiate phraſe, the theme of the week." Engaged in purſuits of this kind, Bonnel Thornton did not very cloſely follow the profeſſion to which his father deſtined him, but lived rather a literary life, employing his pen on various ſubjects. To the daily paper called the *Public Advertiſer*, then in high reputation, he was a frequent contributor; and he once had it in contemplation to treat with Mr Rich for the patent of Covent Garden theatre. In 1764, Mr Thornton married Miſs Sylvia Brathwaite, youngeſt daughter of Colonel Brathwaite, who had been governor of a fort in Africa. In 1766, encouraged, as he ſays himſelf, by the ſucceſs of his friend Colman's Terence, he publiſhed two volumes of a tranſlation of Plautus in blank verſe; propoſing to complete the whole if that ſpecimen ſhould be approved. Theſe volumes contained ſeven plays, of which the *Captive* was tranſlated by Mr Warner, who afterwards completed all that Thornton had left unfiniſhed; and the *Mercator* by Mr Colman. The remaining five are, the *Amphitryon*, *Miles Glorioſus*, *Trinummus*, *Aulularia*, *Rudens*. Some parts of the remaining plays which Thornton had tranſlated are preſerved by his continuator. There can be no doubt that this is the beſt way of tranſlating the old comedies, and that Thornton was well qualified for the taſk; but the work has never been in high favour with the public. Yet Warburton ſaid of it, that "he never read ſo juſt a tranſlation, in ſo pure and elegant a ſtyle." Thornton publiſhed in 1767, *The Battle of the Wigs*, as an additional canto to Garth's Diſpenſary; the ſubject of which was the diſputes then ſubſiſting between the fellows and licentiates.

The life of Thornton was not deſtined to attain any great extenſion: in the prime of his days, while he was ſurrounded by domeſtic felicity, the comforts of fortune, and the reſpect of ſociety, ill health came upon him; and medical aid proving inefficient, he died, of the gout in his ſtomach, May 9. 1768, at only 44 years of age. His wife, a daughter, and two ſons, ſurvived him. Beſides the productions already mentioned, he wrote the papers in the Adventurer marked A; "An Ode to St Cecilia's day, adapted to the ancient Britiſh Muſic," a burleſque performance; "The Oxford Barber;" with many detached eſſays in the public papers. A few letters addreſſed to his Sylvia before they were married, diſplay great tenderneſs, expreſſed with frankneſs and eaſe. A ſmall edition of his works might, with much propriety, be preſented to the public, before it ſhall be too late to aſcertain them all. His character may be taken from his epitaph, written in Latin by his friend Dr Warton, and placed on his monument in Weſtminſter Abbey. It is to this effect: "His genius, cultivated moſt happily by every kind of polite literature, was accompanied and recommended by manners open, ſincere, and candid. In his writings and converſation he had a wonderful livelineſs, with a vein of pleaſantry peculiarly his own. In ridiculing the failings of men, without bitterneſs, and with much humour, he was ſingularly happy; as a companion, he was delightful."

Thornton, Thunder.

THUNDER. There is not one of the appearances of nature which has ſo much engaged the attention of mankind as thunder. The ſavage, the citizen, and the philoſopher, have obſerved it with dread, with anxiety, and with curioſity; and the philoſopher of our times treats the others with a ſmile of condeſcenſion, while he here enjoys the fulleſt triumph of his ſuperiority. 1.

> *Felix qui potuit rerum cognoſcere cauſas,*
> *Atque metus omnes et inevitabile fulmen*
> *Subjecit pedibus.*

But though this grand phenomenon has long engaged the curious attention of philoſophers, it is but very lately that they have been able to explain it; that is, to point out the more general law of nature of which it is a particular inſtance. Inflammable vapours had long furniſhed them with a ſort of explanation. The diſcovery of gunpowder, and ſtill more that of inflammable air, gave ſome probability to the exiſtence of extenſive ſtrata of inflammable vapours in the upper regions of the atmoſphere, which, being ſet on fire at one end, might burn away in rapid ſucceſſion, like a train of gunpowder. But the ſmalleſt inveſtigation would ſhew ſuch a diſſimilarity in the phenomena, and in the general effects, that this explanation can have no value in the eyes of a true naturaliſt. Horrid exploſion, and a blaſt which would ſweep every thing from the ſurface of the earth, muſt be the effects of ſuch inflammation. The very limited and capricious nature of the ravages made by thunder, render them altogether unlike exploſions of elaſtic fluids.

2 Thunder reſembles the electrical ſhock

No ſooner were the wonderful effects of the charged electrical phial obſerved, than naturaliſts began to think of this as exhibiting ſome reſemblance to a thunder-ſtroke (ſee Electricity, *Encycl.* n° 12.); but it was not till toward the year 1750 that this reſemblance was viewed in a proper light by the celebrated Franklin. In a diſſertation written that year, he delivers his opinion at large, and notices particularly the following circumſtances of ſimilarity.

1. The

Thunder. Several remarkable particulars.

1. The colour and crooked form of lightning, perfectly fimilar to that of a vivid electrical fpark between diftant bodies, and unlike every other appearance of light. This angular, defultory, capricious form of an electrical fpark, and of forked lightning, is very fingular. No two fucceffive fparks have the fame form. Their fharp angles are unlike every appearance of motion through unrefifting air. Such motions are always curvilineal. The fpark is like the fimultaneous exiftence of the light in all its parts: and the fact is, that no perfon can pofitively fay in which direction it moves.

2. Lightning, like electricity, always ftrikes the moft advanced objects—hills, trees, fteeples.

3. Lightning affects to take the beft conductors of electricity. Bell wires are very frequently deftroyed by it. At Leven houfe in Fifefhire, in 1733, it ran along a gilded moulding from one end of the houfe to the other, exploding it all the way, as alfo the tinfoil on the backs of feveral mirrors, and the gilding of fcreens and leather hangings.

4. It burns, explodes, and deftroys thefe conductors precifely as electricity does. It diffolves metals; melts wires; it explodes and tears to pieces bodies which contain moifture. When a perfon is killed by lightning, his fhoes are commonly burft. When it falls on a wet furface, it fpreads along it. The Royal William, in Louifburgh harbour, in 1758, received a thunder-ftroke, which diffipated the maintop-gallant maft in duft, and came down on the wet decks in one fpark, which fpread over the whole deck as a fpout of water would have done. This is quite according to electrical laws.

5. It has fometimes ftruck a perfon blind. Electricity has done the fame to a chicken which it did not kill.

6. It affects the nervous fyftem in a way refembling fome of the known effects of electricity. The following is a moft remarkable inftance: —— Campbell, Efq. of Succoth, in Dunbartonfhire, had been blind for feveral years. The diforder was a gutta ferena. He was led one evening along the ftreets of Glafgow by his fervant Alexander Dick, during a terrible thunder ftorm. The lightning fometimes fluttered along the ftreets for a quarter of a minute without ceafing. While this fluttering lafted, Mr Campbell faw the ftreet diftinctly, and the changes which had been made in that part by taking down one of the city gates. When the ftorm was over, his entire blindnefs returned.—We have from a friend another inftance, no lefs remarkable. One evening in autumn he was fitting with a gentleman who had the fame diforder, and he obferved feveral lambent flafhes of lightning. Their faces were turned to the parlour window; and immediately after a flafh, the gentleman faid to his wife "Go, my dear, make them fhut the white gate; it is open, you fee." The lady did fo, and returned; and, after a little, faid, "But how did you know that the gate was open?" He exclaimed, "My God! I faw it open, and two men look in, and go away again," (which our friend alfo had obferved). The gentleman, on being clofe queftioned, could not recollect having had another glance, nor why it had not furprifed him; but of the glimpfe itfelf he was certain, and defcribed the appearance very exactly.

7. Lightning kills; and the appearances perfectly refemble thofe of a mortal ftroke of electricity. The mufcles are all in a ftate of perfect relaxation, even in thofe fituations where it is ufually otherwife.

8. Lightning is well known to deftroy and to change the polarity of the mariner's needle.

3 Dr Franklin difcovered that it was the fame.

Dr Franklin was not contented with the bare obfervation of thefe important refemblances. He availed himfelf of many curious difcoveries which he had made of electrical laws. In particular, having obferved that electricity was drawn off at a great diftance, and without the leaft violence of action, by a fharp metallic point, he propofed to philofophers to erect a tall maft or pole on the higheft part of a building, and to furnifh the top of it with a fine metalline point, properly infulated, with a wire leading to an infulated apparatus for exhibiting the common electrical appearances. To the whole of this contrivance he gave the name of *thunder-rod*, which it ftill retains. He had not a proper opportunity of doing this himfelf at the time of writing his differtation in a letter from Philadelphia to the Royal Society of London; but the contents were fo fcientific, and fo interefting, that in a few weeks time they were known over all Europe. His directions were followed in many places. In particular, the French academicians, encouraged by the prefence of their monarch, and the great fatisfaction which he expreffed at the repetition of Dr Franklin's moft inftructive experiments, which difcovered and eftablifhed the theory of pofitive and negative electricity, as it is ftill received, were eager to execute his orders, making his grand experiment, which promifed fo fairly to bring this tremendous operation of nature not only within the pale of fcience, but within the management of human power.

But, in the mean time, Dr Franklin, impatient of delay, and perhaps incited by the honourable defire of well-deferved fame, put his own fcheme in practice. His inventive mind fuggefted to him a moft ingenious method of prefenting a point to a thunder cloud at a very great diftance from the ground. This was by fixing his point on the head of a paper kite, which the wind fhould raife to the clouds, while the wet ftring that held it fhould ferve for a conductor of the electricity. We prefume that it was with a palpitating heart that Dr Franklin, unknown to the neighbours, and accompanied only by his fon, went into the fields, and fent up his meffenger that was to bring him fuch news from the heavens. He told a perfon, who repeated it in the hearing of the prefent writer, that when he faw the fibres of the cord raife themfelves up like hogs briftles, he uttered a deep figh, and would have wifhed that moment of joy to have been his laft. He obtained but a few faint fparks from his apparatus that day; but returned to his houfe in a ftate of perfect happinefs, now feeling that his name was never to die. Thus did the foap-bubble, and the paper-kite, from being the playthings of children, become, in the hands of Newton and of Franklin, the means of acquiring immortal honour, and of doing the moft important fervice to fociety.

We may juftly confider this as one of the greateft of philofophical difcoveries, and as doing the higheft honour to the inventor; for it was not a fuggeftion from an accidental obfervation, but arofe from a fcientific comparifon of facts, and a fagacious application of the doctrine of pofitive and negative electricity; a doctrine wholly

Thunder. wholly Dr Franklin's, and the refult of the moft acute and difcriminating obfervation. It was this alone that fuggefted the whole; and by explaining to his fatisfaction the curious property of fharp points, gave him the courage to handle the thunderbolt of Jove.

It is then a point fully afcertained, that thunder and lightning are the electric fnap and fpark, as much fuperior to our puny imitations as we can conceive from the immenfe extent of the inftruments in the hands of Nature. If, fays Dr Franklin, a conductor one foot thick and five feet long will produce fuch fnaps as agitate the whole human frame, what may we not expect from a furface of 10,000 acres of electrified clouds? How loud muft be the explofion? how terrible the effects?

4
Electrical ftate of the atmofphere.

This difcovery immediately directed the attention of philofophers to the ftate of the atmofphere with refpect to electricity; and in this alfo Dr Franklin led the way. He immediately erected his thunder rods; and they have been imitated all over the world, with many alterations or improvements, according to the different views and fkill of their authors. It is needlefs to infift here on their conftruction. They have been defcribed in the article Electricity, *Encycl.*; and any perfon well acquainted with its theory, as laid down in the *Supplementary* article Electricity, will be at no lofs to accommodate his own conftruction to his fituation and purpofes.

Dr Franklin took the lead, as we have already obferved, in this examination of the electrical ftate of the atmofphere. He feldom found it without giving figns of electricity, and this was generally negative. See *Phil. Tranf.* Vol. XLVIII. p. 358 and 785.

Mr Canton repeated thofe experiments, and found the fame refults; both, however, found that the electricity would frequently change from pofitive to negative, and from negative to pofitive, in very fhort fpaces of time, as different portions of clouds or air paffed the thunder-rod.

5
Cautions to be obferved in this examination by a thunder rod.

We muft here remark, that our acquaintance with the laws of electricity fufficiently informs us, that the electricity of our thunder-rod may frequently be of a different kind from that of the cloud which excites the appearances at our apparatus. We know that air, like glafs, is a non-conductor; and that when it is brought into any ftate of electricity, either by communication, or by mere induction, it will remain in that ftate for fome time, and that it always changes its electricity *per ftratum.* A pofitive cloud, in the higher regions of the atmofphere, will render the air immediately below it negative, and a ftratum below that pofitive. If the thunder rod be in this pofitive ftratum, it will exhibit pofitive electricity; but if the cloud be confiderably nearer, the rod, by being in the adjoining negative ftratum, may fhew a negative electricity, which will exceed the pofitive electricity which the diftant pofitive cloud would have induced on its lower end by mere pofition, had the intervening air been away. This excefs of negative electricity muft depend on the degree in which the furrounding ftratum of air has been rendered negative. If this has been the almoft inftantaneous effect of the prefence of the pofitive cloud, it cannot be rendered fo negative as to produce negative electricity in the lower end of the thunder-rod. But if the ftratum of air has for fome confiderable time accompanied the pofitive cloud, its negative electricity has been increafing, and fome would remain, even if the cloud were removed. We muft, at all times, confider the thunder rod as affected by *all* the electricity in its neighbourhood. The diftant pofitive cloud would at any rate render the lower end of the rod pofitive, without communication, by merely difplacing the electricity in the rod itfelf, juft as the north pole of a loadftone would make the remote end of a foft iron rod a north pole. In like manner, the negative ftratum of air immediately adjoining to the pofitive cloud would make the lower end of the rod negative, without communication. A pofitive ftratum of air below this would have the contrary effect. The appearances, then, at the end of the rod, muft be the refult of the prevalence of one of thefe above the others; and many intervening circumftances muft be underftood, before we can infer with certainty the ftate of a cloud from the appearances at the lower end of the apparatus. It would, therefore, be a moft inftructive addition to a thunder rod to have an electrofcope at both ends. If they fhew the fame kind of electricity, we may be affured that it is by communication, and is the fame with that of the furrounding ftratum of air: But if they fhew oppofite electricities (which is generally the cafe), then we learn that it is by pofition or induction. We recommend this to the careful attention of the philofopher.

In this way we perfectly explain an appearance which puzzled both of the above-mentioned obfervers. When a fingle low cloud approached the rod, the electrofcope would fhew pofitive electricity, but negative when the cloud was in the zenith, and pofitive again when it had paffed by. We alfo learn from this the caufe of Dr Franklin's difappointment in his expectations of very remarkable phenomena by means of his kite. He imagined that it would be vaftly fuperior to the apparatus which he had recommended to the philofophers of Europe. But the ftring of the kite, traverfing feveral ftrata in different ftates of electricity, ferved as a conductor between them, and he could only obtain the fuperplus; which might be nothing, even when the clouds were ftrongly electrified.

The moft copious and curious obfervations on the electrical ftate of the atmofphere are thofe by Profeffor Beccaria of Turin. He had connected the tops of feveral fteeples of the city by infulated wires. He did the fame thing at a monaftery on a high hill in the neighbourhood. Each of thefe collected the electricity of a feparate ftratum of confiderable extent. He frequently found thefe two ftrata in oppofite ftates of ftrong electricity.

6
Beccaria's general laws of atmofpheric electricity.

The following general obfervations are made out from a comparifon of a vaft variety of more particular ones made in different places:

1. The air is almoft always electrical, efpecially in the day time and dry weather; and the electricity is generally pofitive. It does not become negative, unlefs by winds from places where it rains, fnows, or is foggy.

2. The moifture of the air is the conftant conductor of its electricity in clear weather.

3. When dark or wet weather clears up, the electricity is always negative. If it has been very moift, and dries very faft, the electricity is very intenfe, and diminifhes

Thunder.

niſhes when the air attains its greateſt dryneſs; and may continue long ſtationary, by a ſupply of air in a drying ſtate from diſtant places.

4. If, while the ſky overcaſts in the zenith, only a high cloud is formed, without any ſecondary clouds under it, and if this cloud is not the extenſion of another which rains in ſome remote place, the electricity (if any) is always poſitive.

5. If the clouds, while gathering, are ſhaped like locks of wool, and are in a ſtate of motion among each other; or if the general cloud is forming far aloft, and ſtretches down like deſcending ſmoke, a frequent poſitive electricity prevails, more intenſe as the changes in the atmoſphere are quicker; and its intenſity predicts the great quantity of ſnow or rain which is to follow.

6. When an extenſive, thin, level cloud forms, and darkens the ſky, we have ſtrong poſitive electricity.

7. Low thick fogs, riſing into dry air, carry up ſo much electricity as to produce ſparks at the apparatus. If the fog continues round the apparatus without riſing, the electricity fails.

8. When, in clear weather, a cloud paſſes over the apparatus, low and tardy in its progreſs, and far from any other, the poſitive electricity gradually diminiſhes, and returns when the cloud has gone over.

9. When many white clouds gather over head, continually uniting with and parting from each other, and thus form a body of great extent, the poſitive electricity increaſes.

10. In the morning, when the hygrometer indicates dryneſs equal to that of the preceding day, poſitive electricity obtains, even before ſunriſe.

11. As the ſun gets up, this electricity increaſes; more remarkably if the dryneſs increaſes. It diminiſhes in the evening.

12. The mid-day electricity, of days equally dry, is proportional to the heat.

13. Winds always leſſen the electricity of a clear day, eſpecially if damp: therefore they do not electrify the air by friction on ſolid bodies.

14. In cold ſeaſons, with a clear ſky and little wind, a conſiderable electricity ariſes after ſunſet, at dew falling.

The ſame happens in temperate and warm weather.

If, in the ſame circumſtances, the general dryneſs of the air is leſs, the electricity is alſo leſs.

15. The electricity of dew, like that of rain, depends on its quantity. This electricity of dew may be imtitated by electrifying the air of a cloſe room (not too dry), and filling a bottle with very cold water, and ſetting it in the upper part of the room. As the damp condenſes on its ſides, an electrometer will ſhew very vivid electricity.

Such a collection of obſervations, to be fit for inference, requires very nice diſcrimination. It is frequently difficult to diſcover electricity in damp air, though it is then generally ſtrongeſt; becauſe the inſulation of the apparatus is hurt by the dampneſs. To make the obſervation with accuracy, requires a portable apparatus, whoſe inſulation can be made good at all times. With ſuch apparatus we ſhall never miſs obſerving electricity in fogs, or during ſnow.

[Cu]rious [ph]enomenon of a [tick]ling

There is a very curious phenomenon, which may be frequently obſerved in Edinburgh, and no doubt in other towns ſimilarly ſituated. In a clear day of the month of May, an eaſterly wind frequently brings a fog with it, which advances from the ſea in a denſe body; and when it comes up the High ſtreet, it chills the body exceedingly, while it does not greatly affect the thermometer. Immediately before its gaining the ſtreet, one feels like a tickling on the face, as if a cobweb had fallen on it, and naturally puts up his hand, and rubs the face. We have never found this to fail, and have often been amuſed with ſeeing every perſon rubbing his face in his turn. The writer of this article has obſerved the ſame thing at St Peterſburgh, in a ſummer's evening when a low fog came on about ten o'clock.

The general appearances of a thunder ſtorm are nearly as follows: 7

Phenomena of a thunder ſtorm.

For the moſt part the wind is gentle, or it is calm. A low denſe cloud begins in a place previouſly clear: this increaſes faſt in ſize; but this is only upwards, and in an arched form, like great bags of cotton. The lower ſurface of the cloud is commonly level, as if it reſted on a glaſs plane.

Soon after appear numberleſs ſmall ragged clouds, like flakes of cotton teazled out. Theſe are moving about in various uncertain directions, and continually changing their ragged ſhape. This change, however, is generally by augmentation. Whatever occaſions the precipitation of the diſſolved water ſeems to gain ground. As theſe clouds move about, they approach each other, and then ſtretch out their ragged arms toward each other. This is not by an augmentation, but by a real bending of theſe tatters towards the other cloud They ſeldom come into contact; but after coming very near in ſome parts, they as plainly recede, either in whole, or by bending their arms away from each other.

But during this confuſed motion, the whole maſs of ſmall clouds approaches the great one above it; and when near it, the clouds of the lower maſs frequently coaleſce with each other before they finally coaleſce with the upper cloud: But as frequently the upper cloud increaſes without them. Its lower ſurface, from being level and ſmooth, now becomes ragged, and its tatters ſtretch down towards the others, and long arms are extended towards the ground. The heavens now darken apace, the whole maſs ſinks down; and ariſes, and frequently ſhifts in ſqualls; ſmall clouds are now moving ſwiftly in various directions; lightning now darts from cloud to cloud. A ſpark is ſometimes ſeen co-exiſtent through a vaſt horizontal extent, of a crooked ſhape, and of different brilliancy in its different parts. Lightning ſtrikes between the clouds and the earth—frequently in two places at once. A continuation of theſe ſnaps rarifies the cloud; and in time it diſſipates. This is accompanied by heavy rain or hail; and then the upper part of the clouds is high and thin.

During this progreſs of the ſtorm, the thunder rod is ſtrongly electrified; chiefly when the principal cloud is over head. The ſtate of the electricity frequently changes from poſitive to negative—almoſt every flaſh, however diſtant, occaſions a ſudden ſtart of the electroſcope, and then a change of the electricity. When the cloud is more uniform, the electricity is ſo too. 8

Sources of atmoſpheric electricity.

The queſtion now is, In what manner does the air acquire this electricity? How come its different parts to be in different ſtates, and to retain this difference for a length of time? and how is the electric equilibrium reſtored

Thunder.

reſtored with that rapidity, and that extent, that we obſerve in a thunder ſtorm? For we know that air is a very imperfect conductor, and tranſmits electricity to ſmall diſtances only, and very ſlowly. We ſhall mention ſeveral circumſtances, which are known facts in electricity, and muſt frequently concur, at leaſt, with the other cauſes of this grand phenomenon.

Air is rendered electrical in a great variety of ways.

1. All operations which excite electricity in other bodies have the ſame effect on air. It is electrified by friction. When blown on any body, ſuch as glaſs, &c. that body exhibits electricity by a ſenſible electroſcope. We therefore conclude that the air has acquired the oppoſite electricity from this rubber. A glaſs veſſel, exhauſted of air, and broken in the dark, gives a loud crack, and a very ſenſible flaſh of light. An air-gun, diſcharged (without a ball) in the dark, does the ſame. Blowing on an electric with a pair of bellows never fails to excite it. In ſhort, the facts to this purpoſe are numberleſs.

2. Electricity is produced by a number of chemical operations, which are continually going on. The melting and freezing of electric bodies in contact with each other, ſuch as chocolate in its moulds, wax-candles in their moulds, ſealing wax, &c. Nay, it is highly probable that any body, in paſſing from its fluid to its ſolid form, or the contrary, is electrical. This is the caſe when a ſolution of Glauber's ſalt, or of nitre, in water, is made to cryſtallize all at once by agitation.

The ſolution of bodies in their menſtrua is, in like manner, productive of electricity in many caſes. Thus iron or chalk, while diſſolving in the ſulphuric acid, produce negative electricity in the mixture, and poſitive in the electric vapours which ariſe from them.

A moſt copious ſource of electricity is the converſion of water into elaſtic ſteam by violent heats. When this is done in a proper apparatus, the electricity of the liquid is negative, and the vapour is poſitive. But if this be accompanied by a decompoſition of the water, the liquid is ſometimes ſtrongly negative. Thus, when water evaporates ſuddenly from a red hot ſilver cup, the cup is ſtrongly negative; but if from clean red hot iron, ſo that the iron is calcined, and inflammable air produced, the iron is poſitive. If the decompoſition of the water is ſufficiently copious to do more than compenſate for the negative electricity produced by the mere expanſion of the water into ſteam, the electricity is poſitive; but not otherwiſe. Water expanded from a piece of red hot coal always gives negative electricity, and this frequently very ſtrong. Theſe experiments ſhould always be made in metalline veſſels. If made in glaſs veſſels, the glaſs takes a charge, which expends the produced electricity, and remains neary neutral, ſo that the production of electricity is not obſerved. Theſe facts are to be found among many experiments of Mr Sauſſure. But there is here a very wide field of new inquiry, which cannot fail of being very inſtructive, and particularly in the preſent queſtion. We ſee ſome of the effects very diſtinctly in ſeveral phenomena of thunder and lightning. Thus, the great eruptions of Ætna and Veſuvius are always accompanied by forked lightnings, which are ſeen darting among the volumes of emitted ſmoke and ſteam. Here is a very copious converſion of water into elaſtic ſteam; and here alſo it is moſt reaſonable to expect a copious decompoſition of water, by the iron and coally matters, which are expoſed to the joint action of fire and water. Theſe two electricities will be oppoſite; or when not oppoſite, will not be equal: in either of which caſes, we have vaſt maſſes of ſteam in ſtates fit for flaſhing into each other.

A fact more to our purpoſe is, that if a ſilk or linen cloth, of a downy texture, be moiſtened or damped, and hung before a clear fire to dry, the fibres briſtle up, and on bringing the finger, or a metal knob, near them, they are plainly attracted by it. We found them negatively electric. This ſhews that the ſimple ſolution of water in air produces electricity. And this is the chief operation in Nature connected with the ſtate of the atmoſphere. It is thus that the watery vapours from all bodies, and particularly the copious exſudation of plants, diſappear in our atmoſphere. There can be no doubt but that the oppoſite electricity will be produced by the precipitation of this vapour; that is, by the formation of clouds in clear air. When damp, but clear air in one veſſel expands into an adjoining veſſel, from which the air has been exhauſted, a cloud appears in both, and a delicate electrometer is affected in both veſſels; but our apparatus was not fitted for aſcertaining the kind of electricity produced. Here then is another unexplored field of experiment. We got two veſſels made, having diaphragms of thin ſilk. Theſe were damped, and ſet into two tubs of water, of very different temperatures. Dry air was then blown thro' them, and came from their ſpouts ſaturated with water. The ſpouts were turned toward each other. Being of very different temperatures, the ſtreams produced a cloud upon mixing together, and a ſtrong negative electricity was produced. We even found that an electrometer, placed in a veſſel filled with condenſed air, was affected when this air was allowed to ruſh out by a large hole.

Laſtly, we know that the tourmaline, and many of the columnar cryſtals, are rendered electrical by merely heating and cooling. Nay, Mr Canton found that dry air became negative by heating, and poſitive by cooling, even when it was not permitted to expand or contract.

When water is precipitated, and forms a cloud, it is reaſonable to expect that it will have the electricity of the air from which it is precipitated. This may be various, but in general negative: For the heat by which the air was enabled to diſſolve the water made it negative; and much more the friction on the ſurface of the earth. But as heat cauſed it to diſſolve the water, cold will make it precipitate it; and we ſhould therefore expect that the air will be in the ſtate in which it was when it took up the water. But if it be cooled ſo faſt as to precipitate it in the form of rain, or ſnow, or hail, we may expect poſitive electricity. Accordingly, in ſummer, hail ſhowers always ſhew ſtrong poſitive electricity; ſo does ſnow when falling dry.

Here, then, are copious ſources of atmoſpheric electricity. The mere expanſion and condenſation of the air, and ſtill more the ſolution and precipitation of watery vapours in it, are perhaps ſufficient to account for all the inequality of electric ſtate that we obſerve in the atmoſphere.

The maſſes of air thus differently conſtituted are evidently diſpoſed in ſtrata. The clouds are ſeen to be ſo. Theſe clouds are not the ſtrata, but the boundaries of ſtrata;

Thunder.

ftrata; which, from the very nature of things, are in different ftates with refpect to the fufception or precipitation of water. When two fuch ftrata are thus adjoining, they will flowly act on each other's temperature, and by mixing will form a thin ftratum of cloud along their mutual confines. If the one ftratum has any motion relative to the other, and be in the fmalleft degree difturbed, they will mix to a greater depth in each; and this mixture will not be perfectly uniform. The extreme mobility of air will greatly increafe this jumble of the adjoining parts of the two ftrata, and will give the cloud a greater thicknefs. If the jumble has been very great, fo as to pufh one of them through the other, we fhall have great towering clouds, perhaps pervading the whole thicknefs of the ftratum of air. We take thefe clouds to be like great foggy bladders, fuperficially opaque where they have come into contact with the furrounding ftratum of air, but tranfparent within.

9 Strata of the atmofphere are in different ftates of electricity, and are tranfparent.

When the wind, or ftratum in motion, does not pufh all the quiefcent air before it, it generally gets over it, and then flows along its upper fide, and, by a partial mixing, produces a fleecy cloud, as already defcribed. We may obferve here, by the way, that the motion of thofe fleecy clouds is by no means a juft indication of the motion of the ftratum; it is nearly the motion compofed of the half of the motions of the two.

10 Thefe ftrata have ftrata of clouds interpofed

This is in all probability the ftate of the atmofphere, confifting of ftrata of clear air many hundred yards thick, feparated from each other by thin fleeces of clouds, which have been produced by the mixture of the two adjoining ftrata. This is no fancy; for we actually fee the fky feparated by ftrata of clouds at a great diftance from each other. And we fee that thefe ftrata maintain their fituations, without farther admixture, for a long time, the bounding clouds continuing all the while to move in different directions. In the year 1759, during the fiege of Quebec, a hard gale blew one day from the weftward, which made it almoft impracticable to fend a number of provifion boats to our troops ftationed above the town. While the men were tugging hard at the oars againft the wind, and hardly advancing, though the tide of flood favoured them, the French threw fome bombs to deftroy the boats. One of thefe burft in the air, near the top of its flight, which was about a quarter of a mile high. The round ball of fmoke produced by the explofion remained in the fame fpot for above feven minutes, and difappeared by gradual diffufion. The lower air was moving to the eaftward at leaft 30 feet per fecond.

In 1783, when a great fleet rendezvoufed in Leith Roads, the fhips were detained by an eafterly wind, which had blown for fix weeks without intermiffion. The fky was generally clear; fometimes there was a thin fleece of clouds at a great height, moving much more flowly in the fame direction with the wind below. During the laft eight days, the upper current was from the weftward, as appeared by the motion of the upper clouds. High towering clouds came down the river, with a little rain; the ftrata were jumbled, and the whole atmofphere grew hazy and uniform; then came thunder, and heavy rain, and the wind below fhifted to the weftward.

Thus it is fufficiently evinced, that the atmofphere frequently confifts of fuch ftrata, well diftinguifhed from each other: their appearance and progrefs leave us no room to doubt but that they come from different quarters, and had been taken up or formed at different places, and in different circumftances, and therefore differing in refpect of their electrical ftates.

11 The electric equilibrium is reftored very flowly in general.

The confequence of their continuing long together would be a gradual but flow progrefs of their electricity to a ftate of equilibrium. The air is perhaps never in a perfectly dry ftate, and its moifture will caufe the electricity to diffufe itfelf gradually. It is not beyond the power of our mathematics to afcertain the progrefs of this approximation to the electric equilibrium. We fee fomething very like it in the curious experiments of Beccaria with mirror plates laid together, and charged by means of a coating on the outer plates. Thefe plates were found to confift of alternate ftrata of pofitive and negative electricity. which gradually penetrated through the plates, and coalefced till they were reduced to two ftrata; perhaps in time the electricity would have difappeared entirely by thefe two alfo coalefcing. In the fame manner there would be a flow transfufion of fenfible electricity through thefe ftrata without any fenfible appearances. If any collateral caufes fhould make a part more damp than the reft, there would be a more brifk transference through it, accompanied with faint flafhes of lambent lightning.

12 A rapid and extenfive reftoration in a thunder clap.

But thunder requires a rapid communication, and a reftoration of electric equilibrium in an inftant, and to a vaft extent. The means for this are at hand, furnifhed by Nature. The ftrata of charged air are furnifhed with a coating of cloud. The lower ftratum is coated on the underfide by the earth.

13 Manner in which this is effected by a coating of cloud.

When a jumble is made in any of the ftrata, a precipitation of vapour muft generally follow. Thus a conductor is brought between the electrical coatings. This will quickly enlarge, as we fee that in our little imitations the knobs of our conductors inftantaneoufly arrange any particles of duft which chance to lie in the way, in fuch a manner as to complete the line of conduct, and occafion a fpark to fly to a much greater diftance than it would have leaped if no duft had been interpofed. We have often procured a difcharge between two knobs which were too far afunder, by merely breathing the damp air between them. In this manner the interpofed cloud immediately attracts other clouds, grows ragged by the paffage of electricity through clear air, where it caufes a precipitation by altering the natural equilibrium of its electricity; for a certain quantity of electricity may be neceffary for air's holding a certain quantity of vapour. Accordingly we fee in a thunder ftorm that fmall clouds continually and fuddenly form in parts formerly clear. Whatever caufes thunder does in fact promote this precipitation.

Thefe clouds have the electricity of the furrounding air, and muft communicate it to others in an oppofite ftate, and within reach. They muft approach them, and muft afterwards recede from them, or from any that are in the fame ftate of electricity with themfelves. Hence their ragged forms, and the fimilar form of the under furface of the great cloud; hence their continual and capricious fhifting from place to place: they are carriers, which give and take between the other clouds. and they may become ftepping ftones for the general difcharge.

If a fmall cloud form a communication with the ground.

Thunder. ground, and the great cloud be poſitive or negative, we muſt have a complete diſcharge, and all the electrical phenomena, with great violence; for this coating of vapour is abundantly complete for the purpoſe. It conſiſts of ſmall veſicles, which are ſufficiently near each other for diſcharging the whole air that is in their interſtices. A phial coated with amalgam is by no means fully coated. If we hold it between the eye and the light, we ſhall ſee that it is only covered with a number of detached points of amalgam, which looks like a cobweb. Yet this glaſs is almoſt completely diſcharged by a ſingle ſpark, the reſiduum being hardly perceptible.

14 The diſcharge is commonly between the clouds, The general ſcene of thunder is the heavens; and it is by no means a frequent caſe that a diſcharge is made into the earth. The air intervening between the earth and the loweſt coating is commonly very much confuſed in conſequence of the hills and dales, which, by altering the currents of the winds, toſs up the inferior parts, and mix them with thoſe above. This generally keeps the earth pretty much in the ſame electrical ſtate as the loweſt ſtratum of clouds.

15 Which are horizontally diſtant. Nor are the great thunder ſtorms in general inſtances of the reſtoration of equilibrium between two ſtrata immediately incumbent on each other. They ſeem, for the moſt part, to be ſtrokes between two parcels of air which are horizontally diſtant. This, however, we do not affirm with great confidence. Our chief reaſon for thinking ſo is, that in theſe great ſtorms the ſpark or ſhaft of forked lightning is directed horizontally, and ſometimes is ſeen at once through an extent of ſeveral miles.

16 Particular account of forked lightning, and explanation of the long continued and rumbling noiſe of thunder. The nature of this ſpark has not, we think, been properly conſidered. It is ſimply compared to a long electrical ſpark, which we conceive to be drawn thro' pure air, and is conſidered as marking the actual transference of electricity from one end to the other. But this we doubt very much. We are certain of having obſerved ſhafts of lightning at one and the ſame inſtant ſtretching horizontally, though with many capricious zigzags and lateral ſputterings, at leaſt five miles. We cannot conceive this to have been the ſtriking diſtance, becauſe the greateſt vertical diſtance of the ſtrata is not the half of this. We rather think that it is a ſimultaneous range of diſcharges, each accompanied with light, differently bright, according to the electrical capacity of the cloud into which it is made; and if there is a real transference of electric matter on this occaſion (which we do not affirm), it is only of a ſmall quantity from one cloud to the next adjoining. This we think confirmed by the ſound of thunder. It is not a ſnap, incomparably louder than our loudeſt ſnap from coated glaſs; but a long continued, rumbling, and *very unequable* noiſe. There is no doubt but that this ſnap was almoſt ſimultaneous through the whole extent of the ſpark; but its different parts are conveyed to our ear in time, and are therefore heard by us in ſucceſſion; and it is not an uniform roar, but a rumbling noiſe, unequally loud, according as the different parts of the ſnap are indeed differently loud. We ſhould hear a noiſe of the ſame kind if we ſtood at one end of a long line of ſoldiers, who diſcharged their muſkets (differently loaded) in the ſame inſtant. When any part of the ſpark is very near us, and is not very diffuſe, the ſnap begins with great ſmartneſs, and continues for ſome time, not unlike the violent tearing of a piece of ſtrong ſilk; after which it becomes more and more mellow as it comes from a greater diſtance. We do not, however, affirm, that the whole extenſive ſpark and ſnap are co-exiſtent or ſimultaneous. The cloud is, in all probability, but an indifferent conductor, and even a ſenſible time may elapſe during the propagation of the ſpark to a great diſtance. Beccaria obſerved this in a line of 250 feet of chain, lying looſely on the ground, and conſiſting of near 6000 links. He thought that it employed a full ſecond; but when the chain was gently ſtretched, the communication ſeemed inſtantaneous.

17 Obſervations on the electric ſpark. We cannot help thinking that even the electrical ſnap between two metal knobs is of the ſame kind. Not a quantity of luminous matter which iſſues from the one and goes to the other, but a light that is excited or produced in different material interjacent particles of air or other interpoſed matter. The angular and ſputtering form is quite incompatible with the motion of a ſimple luminous point. Nay, our chemical knowledge here comes in aid, and obliges us to ſpeculate about the manner in which this light is produced. Whence does it come? It may be produced by two knobs of ice. We know that water conſiſts of vital and inflammable air, which have already emitted the light which made an ingredient of their compoſition. The ſpark therefore does not come from the ice. Is it then from the air? If ſo, perhaps water is produced, or rather ſomething elſe, for there is not always inflammable air at hand to compoſe water. Yet the transference of electricity has decompoſed the air, or has robbed it of part of its light. The remainder may not be water; but it is no longer air. Is not this confirmed by the peculiar ſmell which always accompanies electric ſparks? and the peculiar taſte, not unlike the taſte felt on the tongue when it is touched by the zinc in the experiments on GALVANISM? Even the fine pencil of light which flows from a point poſitively electrified, appears through a magnifying glaſs to conſiſt, not of luminous lines, but of lines of luminous points. And theſe points are of different brilliancy and different colour, both of which are inceſſantly changing. And be it farther obſerved, that theſe lines are curves, diverging from each other, and convex to the axis. This circumſtance indicates a mutual repulſion, ariſing, in all probability, from the expanſion of the air. And, laſtly, no ſpark nor light of any kind can be obtained in a ſpace perfectly void of air.

All theſe circumſtances concur in explaining the nature of the ſhaft of forked lightning. It is a ſeries of appearances excited in the intervening medium, and which produces ſome chemical change in it. Thunder, when it ſtrikes a houſe, always leaves a peculiar ſmell. Inflammable air has alſo a peculiar and very diſagreeable ſmell. The ſmell produced by electricity greatly reſembles the ſmell produced by ſtriking two pieces of quartz together.

18 Deluc's notion of thunder not probable. Mr Deluc ſuppoſes that the electrical ſpark, as it is exhibited in thunder, is always accompanied by the decompoſition of air now ſo familiarly known, and that this is the origin of the deluge of rain which commonly finiſhes the ſtorm. But this is not in the ſmalleſt degree probable. The decompoſition extends ſurely no farther than where the light is ſeparated; and we ſhould no more expect a deluge of rain, even if we had inflammable air ready at hand, than we expect drops of water in our electrical experiments. Something different from water

water follows this decompoſition, total or partial, of the vital air; and the water which we do obſerve to accompany thunder, is no more than what we ſhould expect from the copious precipitation of water in a cloudy form. Mr Sauſſure's obſervations aſſure us, that the particles of a cloud are veſicles. Indeed no perſon who has looked narrowly at a fog, or has obſerved how large the particles are of the cloud which forms in a receiver when we ſuddenly diminiſh the denſity of the air, and who obſerves how ſlowly theſe particles deſcend, can doubt of their being hollow veſicles. We cannot perhaps explain their formation; but there they are. We can hardly conceive them receiving the commotion which accompanied the ſnap without collapſing by the agitation. Perhaps the very ceſſation of their electricity may produce this effect. They will therefore no longer float in the air, but fall, and unite, and come to the ground in rain. We may expect this rain to be copious, for it is the produce of two ſtrata of clouds. It greatly contributes to the putting an end to the ſtorm, by paſſing through the ſtrata, and helping to reſtore the equilibrium.

19
Why and how thunder may continue for ſome time.

One may at firſt expect that a ſingle clap of thunder will reſtore the equilibrium of any extent of clouds, and we require an explanation of their frequent repetition before this is accompliſhed. This is not difficult, and the fact is a confirmation of the above theory, which is conſiderably different from the generally received notions of the ſubject. We conſider the ſtratum of clear air as the charged electric; poſitive on one ſide, and negative on the other, and coated with conducting clouds. When the diſcharge is made, the ſtate of electricity is indeed changed through the whole ſtratum, but the equilibrium is by no means completed. The ſtratum is perhaps a quarter of a mile in thickneſs. The diſcharge does not immediately affect all this; but does it ſuperficially, leaving the reſt unbalanced. It is like the reſiduum which is left in a Leyden phial when the diſcharge has been made by means of a ſpark drawn at a diſtance. It is ſtill more like the reſiduum of the diſcharge of a Leyden phial that is coated only in patches on one ſide. Each of theſe patches diſcharge what is immediately under it and round it to a certain ſmall diſtance, but leaves a part beyond this ſtill charged. This redundant electricity gradually diffuſes itſelf into the ſpaces juſt now diſcharged; and, after ſome conſiderable time has elapſed, another diſcharge may be made. In like manner, the electricity remaining in the interior of the ſtratum diffuſes itſelf, comes within the action of the coating, and may be again diſcharged by a clap of thunder. We have a ſtill better parallel to this in Beccaria's experiments with two or more plates of glaſs laid together. After the firſt diſcharge, the internal ſurfaces will exhibit certain electricity. Lay the plates together, and, after ſome time, the electricity of the inner ſurfaces will be different, and another diſcharge may be obtained.

Magnetiſm affords the beſt illuſtration of this. If a magnet be brought near a piece of ſoft iron, lying below a paper on which iron filings are lightly ſtrewed, it will inſtantly induce a north pole on one end and a ſouth pole on the other; and this will be diſtinctly obſerved by the way in which theſe filings will arrange themſelves. But if, inſtead of ſoft iron, we place a bar of hard tempered ſteel, the ſouth pole will be but a ſmall matter removed from the north pole; but by continuing the magnet long in the ſame place, the diſtribution of magnetiſm in the piece of hard ſteel will gradually advance along the bar, and after a long time the neutral point will be almoſt in the middle of the bar, and the ſouth pole will be at the farther end. See MAGNETISM, in this *Suppl.*

20
Moſt thunder ſtrokes are RETURNING STROKES.

We ſaid that the clouds were the uſual ſcenes of the violent electric phenomena. We imagine that the greateſt part of the thunder ſtrokes which have been felt have been of the kind which Lord Mahon, now Lord Stanhope, calls the returning ſtroke. If two clouds A and B are incumbent over the plain a and b; and if A be poſitive and B negative, the earth will be maintained in a negative ſtate at a, and a poſitive ſtate at b. If the diſcharge be now made between the clouds A and B, the electricity muſt inſtantly ruſh up through a conductor at a, and down through one at b, and each place will have a ſtroke. The ſame thing will happen if the negative cloud B is above the poſitive cloud A, but not in ſo great a degree; for the negative electricity at a will now be much leſs than in the other caſe, becauſe it is induced only by the prevalence of the poſitive cloud A over the more remote negative cloud B.

A + —B

a — +b

This returning ſtroke explains, much better than we can by any direct ſtroke, the capricious effects of thunder. A perſon at Vienna received a terrible ſhock by having his hand on a thunder-rod during a violent exploſion which he ſaw above three miles diſtant. Sparks are obſerved at thunder-rods at every the moſt diſtant flaſh of lightning.

21
Beccaria's theory of thunder not juſt.

Beccaria has a different theory of thunder. He imagines that the different parts of the earth are in different ſtates of electricity, and that the clouds are the reſtoring conductors. But this does not accord with what we know of electricity. The earth is ſo good a conductor, that Dr Watſon could not obſerve any time loſt in communicating the electricity to the diſtance of more than four miles. It is very true, that the earth is almoſt always in a ſtate of very unequal, and even oppoſite, electricity in its different parts; but this ariſes from the variety of clouds ſtrongly electrified in the oppoſite way. This induces electricity, or diſturbs the natural uniform diffuſion of electricity, juſt as the bringing magnets or loadſtones into the neighbourhood of a piece of iron, without touching it, renders it magnetical in its different parts. While they continue in their places, the piece of iron will be magnetical, and differently ſo in its different parts.

Such are the thoughts which occur to us on this ſubject. But we by no means affirm that we have given a full account of the procedure of Nature; we have only pointed out ſeveral neceſſary conſequences of the known laws of electricity, and of its production in the atmoſphere by means of natural operations which are continually going on. Theſe *muſt* operate, and produce an electrical ſtate of the atmoſphere greatly reſembling what we obſerve: and we have ſhewn, from the acknowledged doctrines of electricity, how this want of equilibrium may be removed, and muſt be removed, by the ſame operations of Nature. The equilibrium muſt be reſtored by means of the conducting coating furniſhed by the clouds. But theſe may be the leaſt conſiderable of Nature's reſources; and the ſubject is ſtill an unexplored

Thunder.

unexplored field, in the examination of which we may hope to make great progrefs, in confequence of our daily increafing knowledge of the chemical ftate of the atmofphere.

22 Dr Franklin's invention of a guard againft thunder.

Knowledge is valuable chiefly as it is ufeful. No man ever faw the propriety of this apothegm more ftrongly than Dr Franklin, or more affiduoufly adhered to it in the courfe of a long and ftudious life. However greatly we may admire his fagacity, penetration, and logical difcrimination, in the difcoveries he has made in the fcience of electricity, and his difcovery of the identity of electricity and thunder, we muft acknowledge infinitely greater obligations to him for putting it in our power to ward off the fatal, and formerly inevitable ftroke, of this awful agent in the hands of Nature.

Dr Franklin confiders the earth as performing the office of a conductor in reftoring the electric equilibrium of the atmofphere, which has been difturbed by the inceffant action of the unwearied powers of Nature.

He obferves that the ufual preference will be given to the beft conductors. In this refpect, a metal rod far furpaffes the brick, ftone, timber, and other materials which compofe our buildings, efpecially when they are dry, as is ufually the cafe in the thundery feafon. He therefore advifes us to place metalline conductors in the way of the atmofpherical electricity, in thofe places where it is moft likely to ftrike, and to continue them down to the moift earth, at fome depth under the furface. Nay, as it has been found that thunder has not in every inftance ftruck the higheft parts of buildings, he advifes to raife the metalline conductors to fome confiderable height above the building, the more certainly to invite the electricity to take this courfe.

23 Directions for conftructing it.

To enfure fuccefs, he obferves that the electrical fhock diffipates water, and even metalline conductors, when too fmall. He therefore advifes to make the conductor at leaft half an inch fquare, none of that fize having ever been deftroyed, though fmaller have, by the thunder; yet even thefe had conducted the thunder to the ground with perfect fafety to the building.

No part of a conductor muft terminate in the building; for the electricity accumulates exceedingly at the remote extremities of all long rods, and tends to fly off with great force, efpecially if another conductor is near. This aids the accumulation, by acquiring at its upper end an electricity oppofite to that of the lower end of the other: and this effect, produced by the influence of a pofitive cloud, makes the upper and negative end of the lower portion of a divided conductor draw more electricity to the lower end of the upper portion. This redundant electricity, ftrongly attracted by the negative lower portion, flies off with great violence through the air; or if furrounded with any matter capable of converfion into elaftic vapour by heat, burfts it with irrefiftible force. Thus the thunder, acting on the vane fpindle of St Bride's fteeple in London, fprung from its lower end to the upper end of an iron window bar, and burft the ftone in which it was fixed, by expanding the moifture into fteam. In like manner it burft the ftone at the lower end of this bar, to make its way to an iron cramp which connected the oppofite fides of the fteeple; from this it ftruck to another cramp; and fo from cramp to cramp, till it reached the gutter-leads of the church, burfting and throwing off the ftonework in many places.

All interruptions muft therefore be carefully avoided, and the whole muft be made as much as poffible one continued metal rod.

Farther, Dr Franklin, obferving the fingular property which fharp points poffefs of drawing off the electricity in filence, advifes us to finifh our conductor with a fine point of gilt copper, which cannot be blunted by ruft.

24 Is the thunder rod an effectual and fafe contrivance?

But as thus raifing the conductor, and pointing it, are fo many invitations to the thunder to take this courfe; and as we cannot be certain that the quantity thus invited may not be more than what the rod can conduct with fafety—it has appeared to Dr Wilfon, and other able electricians, that it will be fafer to give abundance of conduct to what may unavoidably vifit us, without inviting what might otherwife have gone harmlefsly by.

This was attentively confidered by Dr Franklin, Dr Watfon, Mr Canton, Dr Wilfon, and others, met as a committee of the Royal Society, at the defire of the Board of Ordnance, to contrive a conductor for the powder magazine at Purfleet.

We think that the theory of induced electricity, founded on Dr Franklin's difcoveries, and confirmed by all the later inventions of the electrophorus, condenfer, &c. will decide this queftion in the moft fatisfactory manner.

25 Scientific account of the ftate of electricity induced on a building by a thunder cloud,

When a cloud pofitively electrified comes over a building, it renders it negatively electrical in all its parts, if of conducting materials, and even the ground on which it ftands. This effect is more remarkably produced if the ftructure is of a tall and flender fhape, like a fteeple or a rod. Therefore the external electrical fluid is attracted by the building with greater force than if it had confifted of materials lefs conductive. A difcharge will therefore be made through it in preference to any neighbouring building, becaufe it is more eminently negative. For the fame reafon, if there are two buildings equal and fimilar, one of them being a good conductor, and the other being a lefs perfect one, the perfect conductor, becoming more powerfully negative, the cloud will become more ftrongly pofitive over this houfe than over the other, and the ftroke will be made through it.

26 And on the thunder rod.

The fame thing muft obtain in a perfect conductor continued from the top to the foundation of a houfe, built of worfe conducting materials. The conductor becoming more eminently negative than any other part of the building, the electric fluid will be more ftrongly attracted by it, accumulated in its neighbourhood, and will all be difcharged through it, fo long as it is able to conduct.

If the building is of great extent, the proximity of one part of the building to the thunder cloud may produce an accumulation of electrical fluid in its neighbourhood, in preference to a more perfect, but remote, conductor. But when the diftances from the cloud are not very unequal, the accumulation will always be in the neighbourhood of the perfect conductor; and this will determine the difcharge that way. The accumulation in the neighbourhood of the rod will be fmall indeed, when the rod is fmall; but then it is denfe, and the whole of electric phenomena fhew that it is the denfity,

denfity, and not the quantity, of accumulation which produces the violent tendency to fly off: it is this alone which makes it impoffible to confine electricity in a body which terminates in a fharp point.

For the fame reafon, bodies of the fame materials and fhape will increafe the accumulation in the adjoining part of the cloud in proportion as they are nearer to it, or more advanced beyond the reft of the building.

And bodies of flender fhape, and pointed, will produce this accumulation in their neighbourhood in a ftill more remarkable degree, and determine the courfe of the difcharge with ftill greater certainty.

But it is evident that a metallic rod, no higher than the reft of the building, may occafion an accumulation in the adjoining part of a near thunder cloud fufficient to produce a difcharge, when the building itfelf, confifting of imperfect conductors, would not have provoked the difcharge at all. It may therefore be doubted whether we have derived any advantage from the conductor.

27 Effect of all interruptions in the conductor.

To judge properly of this, we muft confider houfes as they really are, confifting of different materials, in very different fhapes and fituations; and particularly as having many large pieces of metal in their conftruction, in various pofitions with regard to the cloud, the ground, and to each other. Suppofe all the reft of the building to be of non-conducting materials. When a pofitive thunder cloud comes overhead, every piece of metal in the building becomes electrical, without having received any thing as yet from the cloud; that end of each which is neareft the cloud becoming negative, and the remote end pofitive. But, moreover, the electricity of one increafes the electricity of its neighbour. Then the moft elevated becomes more ftrongly attractive at its upper end than it would have been had the others been away; and therefore produces a greater accumulation in the nearer part of the thunder cloud than it would otherwife have done, and it will receive a fpark. By this its lower end becomes more overcharged, and this makes the upper end of the next more undercharged, and the fpark is communicated to it, and fo on to the ground; which would not have happened without this fucceffion of conductors. Thus it is eafy to conceive, that the accumulation in the cloud is juft infufficient to produce a difcharge—While things are in this ftate, juft ready to fnap, fhould a man chance to pafs under a bell wire, or under a luftre hanging by a chain, his body will immediately augment the pofitive electricity of the lower end of the conductor above him, and thus will augment the negative electricity of its upper end. This again will produce the fame effect in the conductor above it: and thus each conductor becomes more overcharged at its lower end, and more undercharged at the upper end. Before this, every thing was juft ready to fnap. All will now ftrike at once. The cloud will be difcharged through the houfe, and the man will be the facrifice, the whole difcharge being made through his body. This needs no demonftration for any well-informed electrician. Thofe who have only fuch a knowledge of the theory as can be gathered from the writings of Prieftley, Cavallo, and other popular authors, may convince themfelves of the truth of what is here delivered in the following manner.

In dry weather, and the moft favourable circumftances for good electrical experiments, let a very large globe, fmoothly covered with metal, and well infulated, be as highly electrified as poffible, without expofing it to a rapid diffipation. To enfure this circumftance (which is important) let it be electrified till it begins to fputter, and note the ftate of the electrometer. Difcharge this electricity, and electrify it to about half of this intenfity. Provide three or four infulated metal conductors, about three inches long and an inch diameter, terminated by hemifpheres, and all well polifhed.

Having electrified the globe, as above directed, bring one of the infulated conductors flowly up to it, and note its diftance when it receives a fpark. In doing this, take care that there be no conducting body near the remote end of the infulated conductor. It will be beft to pufh it gradually forward by means of a long glafs rod. Withdraw the conductor, difcharge its electricity, reftore the globe to its former electricity, indicated by an electrometer, and repeat this experiment till the greateft ftriking diftance is exactly difcovered. Now fet another of the infulated conductors about half an inch behind the firft, and pufh them forward together, by a glafs rod, till a fpark is obtained. The ftriking diftance will be found greater than before. Then repeat this laft experiment, with this difference, that the two conductors are pufhed forward by taking hold of the remote one. The ftriking diftance will be found much greater than before. Laftly, pufh forward the two conductors, the remote one having a wire communicating with the ground, till they are a fmall matter *without* the ftriking diftance; and, leaving them in this fituation, take any little conducting body, fuch as a brafs ball fixed on the end of a glafs rod, and pafs it brifkly through between the globe and the neareft conductor, or through between the two conductors, taking care that it touch neither of them in the paffage. It will be feen that, however fwift the paffage is made, there will be a difcharge through all the four bodies. The inference from this is obvious and demonftrative.

A very remarkable inftance of this fact was feen at the chapel in Tottenham Court Road, London. A man going into the chapel by the eaft door, was killed by the thunder, which came down from the little bellhoufe, along the bell-wire, and the rod of the clock pendulum, from the end of which it leaped to fome iron work above the door, and from thence, from nail to nail, till it reached the man's head.

This interruption of conduct, which is almoft unavoidable in the conftruction of any building, is the caufe of moft of the accidents that are recorded; for when the ends of thofe communicating conductors are inclofed in materials of lefs conducting power, the electricity, in making its way to the next in a very denfe ftate, never fails to explode every thing which can be converted into elaftic vapour by heat. There is always a fufficient quantity of moifture in the ftone or brickwork for this purpofe; and moft vegetable fubftances contain moifture or other expanfible matter. The ftone, brick, or timber, is burft, and thrown to a confiderable diftance; or if kept together by a weight of wall, the wall is fhattered. It is worth remarking, that although no force whatever feems able to prevent this explofion, the quantity of matter exploded is extremely fmall; for the ftones are never thrown to a greater diftance than they would have been by two or three grains of gunpowder properly confined.

All

All thefe accidents will be prevented by giving a fufficient uninterrupted conduct; and it is proper to make ufe of fuch a conductor, although it may invite many difcharges which would not otherwife happen. So long as the conductor is fufficient for the purpofe, there feems to be no doubt of the propriety of this maxim.

28
A thunder rod will protect even when it is not able to difcharge the whole thunder.

But the moft ferious objection remains. As we are certain that thefe conductors, whether raifed above the building or not, will produce difcharges through them which otherwife would not have happened, and as we are quite uncertain whether the quantity contained in a thunder cloud may not greatly exceed what the thunder rod can conduct without being diffipated in fmoke, it feems very dangerous thus to invite a ftroke which our conductor may not be able to difcharge. In particular, it is reafonable to believe that the ftrata of electrified clouds which come near the earth lofe much of their electricity by paffing over the fharp points of trees, &c. while thofe which are much higher may retain their electricity undiminifhed, and pafs on. May it not therefore happen, that our conductor will invite a fatal ftroke, which would have gone harmlefs by?

The doubt is natural, and it is important.

Let us fuppofe a very extenfive and highly electrified cloud, in a pofitive ftate, to come within fuch a diftance from a building as *juft not to ftrike it*, if unprovided with a conductor, but which will moft certainly ftrike the fame building furnifhed with a conductor; and let the electricity be fo great that the conductor fhall be diffipated in fmoke before even a fmall part of it is difcharged—What will be the fate of the building? We believe that it will be perfectly fafe.

However rapid we may fuppofe that motion by which electricity is communicated, it is ftill motion, and time elapfes during the propagation. The cloud is difcharged, not in a very inftant, but in a very fhort time. Part of the cloud is therefore difcharged, while it explodes the conductor, and the electricity of the remainder is now too weak (by our fuppofition) to ftrike the building no longer furnifhed with a conductor. This muft be the cafe, however large and powerful the cloud may be, and however fmall the conductor.

But fuppofe that the cloud has come fo near as to ftrike the building unprovided with a conductor. Then as much will be difcharged through the building as it can conduct; and if the quantity be too great, the building will be deftroyed: but let a conductor (tho' infufficient) be added. The difcharge will be made through it as long as it lafts, and the remainder only will be difcharged through the houfe, furely with much lefs danger than before.

The truth of thefe conclufions from theory is fully verified by fact. When the church of Newbury in New England was ftruck by lightning in 1755, a bell wire, no bigger than a knitting needle, conducted the thunder with perfect fafety to the building as far down the fteeple as the wire reached, though the ftroke was fo great that the wire had been exploded, and no part of it remained, but only a mark along the wall occafioned by its fmoke. From the termination of the wire to the ground the fteeple was exceedingly fhattered, and ftones of great weight were thrown out from the foundation (where they were probably moifter) to the diftance of 20 and 30 feet.

Another remarkable inftance happened in the fummer palace at St Peterfburg. A Heyduk and a foldier of a foot regiment were ftanding centinels at the door of the jewel-chamber: the Heyduk, with his fcimitar refting on his arm, was carelefsly leaning on the foldier, who had his mufket fhouldered. Both were ftruck down with lightning; and the foldier was killed, his left leg fcorched, and his fhoes burft. The Heyduk had received no damage, but felt himfelf tripped up, as if a great dog had run againft him. A narrow flip of gold lace, which was fewed along the feam of his jacket and pantaloon breeches, reaching to his fhoes, had been exploded on the left fide. This feems to have been his protection. In all probability, the ftroke came to both along the mufket (or perhaps to the Heyduk along the fcimitar). The Heyduk had a complete, though infufficient, conductor, and was fafe. The foldier had not, and was killed. The pufh felt by the former probably arofe from the explofion of the lace.

It feems therefore plain that metalline conductors are always a protection; that advancing them above the building, increafes their protection; and that pointing them may fometimes enable them to diminifh a ftroke, by difcharging part of the electricity filently.

Dr Franklin having formed all his notions of thunder from his pre-eftablifhed theory, and having feen the principal phenomena fo conformable to it, was naturally led to expect this conformity in cafes which he could not eafily examine precifely by experiment. Accordingly in his firft differtation, he affirmed that a fine point always difcharges a thunder cloud filently, and at a great diftance. The analogous experiments in artificial electricity are fo beautiful and fo perfpicuous, that this confidence in the protecting power of fine points is not furprifing: and this confidence was rendered almoft complete by a moft fingular cafe which fell under his own obfervation. He was awakened one night by loud cracks in his ftair-cafe, as if fome perfon had been lafhing the wainfcoating with a great horfewhip. He thought it fo, and got up in anger to chide the idle fool. On looking out at his chamber door, he faw that the difturbance proceeded from electric explofions at fome interruptions of his conductor. He faw the electricity pafs, fometimes in bright fparks, producing thofe loud thwacks, and fometimes in a long continued ftream of denfe white dazzling light as big as his finger, illuminating the ftair-cafe like funfhine, and making a loud noife like a cutler's wheel. Had the cloud (fays he) retained all this till it came within ftriking diftance, the confequences would have been inconceivably dreadful. Yet not long after this he found that he had been in a miftake; for the houfe of Mr Watt in Philadelphia, furnifhed with a finely pointed conductor, was ftruck by a terrible clap of thunder, and the point of the conductor was melted down about two inches. This is perhaps the only inftance on record of a finely-pointed *conductor* being ftruck. The board room at the powder magazine at Purfleet was indeed ftruck, though provided with a conductor; but the ftroke was through another part of the building. St Peter's church, Cornhill, has been eight times ftruck between 1772 and 1787; while St Michael's, in its neighbourhood, and much higher, has never had a ftroke fince 1772, when it was furnifhed with an excellent pointed conductor by Mr Nairne.

Dr

Thunder.

29 Pointed conductor may sometimes be struck.

Dr Franklin having feen the above exception to his rule, and reflected on it, acknowledges that there are cafes where a pointed conductor may be ftruck, viz. when it ferves as a ftepping ftone, to *complete* a canal of conveyance already near completed. A *fmall* cloud may fometimes ferve as a ftepping ftone (like the man coming under a luftre) for the electricity to come out of a great cloud, and difcharge through the pointed conductor. Whenever it comes to the ftriking diftance from the conductor, it will explode at once: whereas the great cloud itfelf muft have come nearer, and had its force gradually diminifhed. It is remarkable that a point, employed in this way in artificial electricity, muft be brought nearer to another body than a ball need be, before it can receive a ftroke. The difference is about one third of the whole Nairne found, that a ball one nine-tenths inches in diameter, exploded at the diftance of nine inches, and a point at fix inches diftance.

We muft alfo obferve that a pointed conductor can have no advantage over a blunt one in the cafe of a returning ftroke; which is perhaps the moft common of any. This depends on another difcharge, which is made perhaps at a great diftance. This was moft diftinctly the cafe in the inftance mentioned fome time ago, of the perfon at Vienna who had a fhock from a thunder rod by an explofion far diftant. This thunder rod was a very fine one, furnifhed with five gilt points

30 Franklin over-rated the protection of pointed conductors.

Still, however, this property of fharp points was greatly over-rated by Dr Franklin, and thofe who took all their notions of electricity from the fimple difcoveries of his fagacious mind. Unfortunately Dr Franklin had not cultivated mathematical knowledge; and, ever eager after difcovery, and ardent in all his purfuits, his wonderful penetration carried him through, and feldom allowed him to reft long on falfe conclufions. He was certainly one of the greateft *philofophers*; and a little erudition would perhaps have brought him fide by fide with Newton. It was referved, however, for Lord C. Cavendifh and for Æpinus, to fubject the inveftigations of Franklin to number and meafure. By ftudying what they have written on the fubject, or even the view which we have given of their theory in the article ELECTRICITY *(Suppl.)*, the reader will be fully convinced, that a point has little or no advantage over a ball, with refpect to a thunder cloud which is brought to the thunder rod by a brifk wind; although, when it comes flowly up during an almoft perfect calm, it may difcharge all that can be difcharged without a fnap. The conftipation in a point is indeed very great, but the quantity conftipated is moderate; and therefore its action, at any confiderable diftance, is but trifling. All this is fully verified by Dr Wilfon's judicious experiments in the Pantheon. He had a prodigious quantity of electrified furface fufpended there, and made a pointed apparatus come to its ftriking diftance with a motion which he could regulate and meafure. And he found that with the very moderate velocity of twelve feet in a fecond, he never failed of procuring a very fmart ftroke. The experiments made in the ufual way by the partifans of fharp points (for it became a matter of indecent party) were numberlefs, and decidedly in their favour. The great and juft authority of Dr Franklin, who was one of the committee, procured them ftill more confideration, or at leaft hindered people from feeing the force of Dr Wilfon's reafoning. It is fomewhat furprifing, that Dr Wilfon, a lover of mathematical learning, and a good judge, as appears from his publication of the papers of Mr Robins, did not himfelf fee the full force of his own experiments. He had not furely ftudied either Æpinus or Cavendifh. He indeed frequently fays, that the ftate of the electricity in a thunder cloud, and in coated glafs, is exceedingly different; and that the firft extends its fenfible influence much farther than the laft, when both have the fame quantity of electricity. But he feems not to have formed to himfelf any adequate notion of the difference. Had he done this, he would have feen that he has difpofed his great electrified furface very improperly. It fhould have been collected much nearer his pointed apparatus, that this might, if poffible, have been within the fphere of attraction of every part of his artificial cloud. He would then have found refults, fome of which would have been much more favourable to his own general opinion, while others would have exhibited the peculiarities of the fharp point in a more fhowy manner than any thing we have feen.

31 Thunder cloud very unlike coated glafs;

Reafoning from the true theory of coated glafs, we fhall learn that, when the glafs is exceedingly thin, the accumulation of electricity, or the charge, will be exceedingly great; while the external appearance, or apparent energy, of the electricity may be hardly fenfible, and will extend to a very fmall diftance. Thus, a circular plate of coated glafs, fix inches in diameter and one-twentieth thick, when electrified fo as to make an electrometer diverge 50 degrees, contains about 60 times as much electricity as a brafs plate, of the fame diameter, electrified to the fame degree; and thefe two will have the fame influence on an electrometer placed at a diftance from them, and will give a fpark nearly at the fame diftance. The fpark from the coated glafs will be bright, and will give a fhock; while that from the brafs plate will be trifling. The caufe of the equality of influence is, that the pofitive electricity of the one fide of the coated glafs is almoft balanced by the negative electricity of the other fide, and the unbalanced part is about $\frac{1}{59}$th of the whole. If we now take a brafs plate of $46\frac{1}{2}$ inches in diameter, and electrify it to the fame degree with the coated glafs, we fhall find that it will require the fame number of turns of the machine to bring it to this ftate, or to charge the coated glafs. They contain the fame quantity of electricity, and the fpark of both will give the fame fhock. But this large plate will have a much wider influence: a perfon coming within ten feet of it will fee his hair bend towards it, and feel like a cobweb on his face.

32 And the influence of fharp points is trifling.

It may be farther demonftrated that the power of a point to abftract the electricity to a given degree from the large plate, is vaftly fmaller than its power to abftract it to the fame degree from the coated plate. This is different in the different degrees of the abftraction, and cannot be expreffed by any one number.

All thefe confiderations taken together, fhew us that the pointed conductor has little advantage over the ball in the circumftance above-mentioned. It has, however, an advantage, and therefore fhould be employed; and in the cafe of a calm, or very gentle progrefs of the thunder cloud, the advantage may be very great.

Thus we think the queftion decided; and the only remaining confideration is the quantity of metallic conduct that fhould be given. Prudence teaches us not to fpare, Thunder || Tiberias.

33 An extensive and substantial metalline conductor is the chief security.

fparc, efpecially in very lofty buildings. The conductor on the dome of St Paul's in London confifts of four iron ftraps, each four inches broad and one half an inch thick. This conductor was once made red hot by a thunder ftroke. No inftance has been found of a rod one-half an inch fquare being exploded. The accident at Mr Watt's houfe in Philadelphia is curious. The brafs wire which terminated the rod had been ten inches long and one-fourth thick at the bafe, and two one-half inches were melted. It was unable, therefore, to conduct that ftroke when its diameter was lefs than one-fixteenth of an inch.

We recommend lead or copper in preference to iron. Iron waftes by ruft, and by exfoliating retains water, which may be dangerous by its expanfion. A ftrap of lead, two inches broad and one-fourth thick, ftapled down to the roof or wall with brafs ftaples, fecures us from all rifks from neglect. An iron rod, or one faftened with iron cramps, requires frequent infpection, to fee that nothing has failed or wafted by ruft. The point or points fhould furely be copper. It would be very proper to connect all the leads of the ridges, gutters, and fpouts, with the conductor, by ftraps of lead. This will greatly extend its protection.

A great extent of building is not fufficiently fecured by one conductor. And a powder magazine fhould have fome erected round it at a diftance on mafts.

Maxims in a Thunder Storm.

Avoid being under trees—but be near them: do not avoid rain. When in a room, avoid the fire-fide, which would bring you into the neighbourhood of the higheft part of the houfe, viz. the ftack of chimneys. The bell-wire, the grate, the fire irons—are bad neighbours. Nay, the foot of the chimney is not a good one, efpecially if it has ever caked together by burning (A). Go to the middle of the room, and fit down, if not near a luftre, or any thing hanging from the ceiling. Avoid mirrors, or gilded mouldings.

Thunder Clouds, in phyfiology, are thofe clouds which are in a ftate fit for producing lightning and thunder. See the preceding article.

THUS, in fea language, a word ufed by the pilot in directing the helmfman or fteerfman to keep the fhip in her prefent fituation when failing with a fcant wind, fo that fhe may not approach too near the direction of the wind, which would fhiver her fails, nor fall to leeward, and run farther out of her courfe.

TIBERIAS (anc. geog.), the laft town of Gallilee, fituated on the fouth fide of the lake Tiberias; built by Herod the Tetrarch, and called *Tiberias* in honour of the Emperor Tiberius; diftant 30 ftadia from Hippus, 60 from Gadara, and 120 from Scythopolis: whence it appears to have been at no great diftance from where the Jordan runs out of the lake. It is a number of times mentioned by St John the Evangelift. Pliny places it on the weft extremity of the lake, commending the falubrity of its hot waters. Jerome fays, the ancient name was *Chennereth*; which, if true, will account for the name of the lake.

Tierra Fuego || Tillandsia.

TIERRA del Fuego, feveral iflands at the fouthern extremity of America. They take their name from a volcano on the largeft of them. They are all very barren and mountainous; but from what Mr Forfter fays, in his Voyage to the South Sea, the climate does not appear to be fo rigorous and tempeftuous as it is reprefented in Anfon's Voyage. Upon the lower grounds and iflands, that were fheltered by the high mountains, Mr Forfter found feveral forts of trees and plants, and a variety of birds. Among the trees was Winter's bark-tree, and a fpecies of *arbutus*, loaded with red fruit of the fize of fmall cherries, which were very well tafted. In fome places there is alfo plenty of celery. Among the birds was a fpecies of duck, of the fize of a goofe, which ran along the fea with amazing velocity, beating the water with its wings and feet. It had a grey plumage, with a yellow bill and feet, and a few white quill feathers. At the Falkland iflands it is called a *loggerhead-duck*. Among the birds are alfo plenty of geefe and falcons. The rocks of fome of the iflands are covered with large mufcle-fhells, the fifh of which is well-flavoured. The natives of this country are fhort in their perfons, not exceeding five feet fix inches at moft, their heads large, their faces broad, their cheek bones prominent, and their nofes flat. They have little brown eyes, without life; their hair is black and lank, hanging about their heads in diforder, and befmeared with train-oil. On the chin they have a few ftraggling fhort hairs inftead of a beard. The whole affemblage of their features forms the moft loathfome picture of mifery to which human nature can poffibly be reduced. Thofe which Mr Forfter faw had no other clothing than a fmall piece of feal-fkin, which hung from their fhoulders to the middle of their back, being faftened round the neck with a ftring: the reft of their body was perfectly naked. Their natural colour feems to be an olive brown, with a kind of glofs, refembling that of copper; but many of them difguife themfelves with ftreaks of red paint, and fometimes, though feldom, with white. Their whole character is a ftrange compound of ftupidity, indifference, and inactivity. They have no other arms than bows and arrows; and their inftruments for fifhing are a kind of fifh-gigs. They live chiefly on feals flefh, and like the fat oily part moft. There is no appearance of any fubordination among them; and their mode of life approaches nearer to that of brutes than that of any other nation.

TILLANDSIA, the large barren wild pine of the

(A) In the terrible thunder ftroke on Leven Houfe in Scotland, the two great ftreams of electricity had taken the courfe of the vents which had been moft in ufe, but not to get at the iron work, for it had branched off from the vents, at a great diftance from the bottom. The chief conductors through the building had been various gilded mouldings, gilded leather hangings, gilded fkreens, picture frames, and the foil of mirrors. In this progrefs the fteps have been fo many, and fo capricious, that no line of progrefs can be traced, according to any principle. The thunder feems to have electrified at once the whole of the leaden roof, and, befides the two main tracks along the vents, to have afterwards darted at every metal thing in its way. The loweft point of the track was a leaden water ciftern; which, however, received no damage; but a thick ftone wall was burft through to get at it.

the West Indies; a genus of the monogynia order, belonging to the hexandria class of plants. It is called *Caragatua* by Father Plumier, and is a parasitic plant, and ought perhaps, in strict propriety, to be denominated an *aquatic:* for although it is suspended in the air among the branches of lofty trees, to whose boughs it is fastened by its numerous roots; yet it is not indebted to those boughs, like the misletoe and other parasitic plants, for nourishment, but merely for support; provident Nature having, in a very extraordinary manner, supplied this with other means to preserve its existence: For the leaves, which much resemble those of the pine-apple, but are larger, surround this plant in a circular manner; each leaf being terminated near the stalk with a hollow bucket, which contains about half a pint of water. It is by these numerous small reservoirs of water that the roots, as well as every other part of this plant, are supplied with nourishment without the help of any earth. The flourishing condition of this plant, as well as the great growth of fig-trees, upon barren rocks, shews that water is of greater use to vegetation than earth.

One contrivance of Nature in this vegetable, says Dr Sloane, is truly admirable. The seed is crowned with many long downy threads, not only that it may be carried everywhere by the wind, but that by those threads, when driven through the boughs, it may be held fast, and stick to the arms and prominent parts of the barks of trees. So soon as it sprouts or germinates, although it be on the under part of a bough, its leaves and stalks rise perpendicular or erect: if they assumed any other direction, the cistern or reservoir just mentioned, made of the hollow leaves, could not hold water, which is necessary to the life and nourishment of the plant. In scarcity of water this reservoir is useful, not to the plant only, but to men, and even to birds and all sorts of insects, which come thither in troops, and seldom go away without refreshment.

To the same purpose, Dampier, in his voyage to Campeachy, relates, "that the wild pine has leaves that will hold a pint and a half or quart of rain-water, which refreshes the leaves, and nourishes the roots. When we find these pines, we stick our knives into the leaves, just above the root; and the water gushing out, we catch it in our hats, as I myself have frequently done, to my great relief."

TIMÆUS, a Greek historian, the son of Andronicus, who was eminent for his riches and excellent qualities, was born at Tauromentum in Sicily, and flourished in the time of Agathocles. He wrote several books, and among the rest an history of his own country; but they are all lost.

TIMÆUS, a famous Pythagorean philosopher, was born at Locres in Italy, and lived before Plato. There is still extant a small treatise of his on Nature and the Soul of the World, written in the Doric dialect. This treatise, which is to be found in the works of Plato, furnished that great philosopher with the subject of his treatise intitled *Timæus.*

TINNING, the covering or lining of any thing with melted tin, or with tin reduced to a very fine leaf. Looking-glasses are foliated or *tinned* with thin plates of beaten tin, by a process described under the title FOLIATING, *Encycl.*

Kettles, sauce-pans, and other kitchen utensils, which are usually made of copper, are tinned by the following process: The surface to be tinned, if of new copper, should first be cleaned or scoured with salt and sulphuric acid (vitriolic acid) dilated with water. This, however, is not always done; some workmen contenting themselves with scouring it with sand perfectly dry, or with scales of iron. Powdered rosin is often strewed over it; and when the vessel or utensil is considerably heated, melted tin is poured into it, and rubbed with flax coiled hard over the surface to be coated. This tin may be either pure, such as that known by the name of *grain-tin;* or a composition consisting of two parts of tin and one of lead. For very obvious reasons, we should certainly prefer the pure tin; but the generality of workmen give the preference to the composition, because the surface coated with it appears more brilliant. The tin is not always put into the vessel in a liquid state; for some workmen strew it in small pieces over the surface to be coated, and then heat the vessel till the tin melt, when they rub it as formerly.

In tinning old vessels which have been tinned before, the process is somewhat different. In these cases, the surface is first scraped with an instrument proper for the purpose, or scoured with the scales of iron, which may be always found in a blacksmith's shop: it is then strewed over with sal-ammoniac in powder, instead of rosin, or an infusion of sal-ammoniac in stale urine is boiled in it till the urine be evaporated, and it is then tinned with pure tin; the composition of tin and lead being in this case never used. The tin, while liquid, is rubbed into the surface with a piece of sal-ammoniac, instead of a bundle of flax. When iron vessels are to be tinned, they are first cleaned with muriatic acid, after which the process is the same as in the tinning of old copper.

In the year 1785, Mr John Poulain of Mortlake, Surrey, obtained a patent for the discovery of a new composition for tinning vessels, especially such as are used for culinary purposes. This composition consists of grain-tin one pound, good malleable iron one ounce and a half, platinum one drachm, silver one pennyweight, gold three grains: the whole must be well fused together in a crucible, with one ounce of pounded borax, and two ounces of pounded glass, and then cast in small ingots. The composition, to be fit for use, must be heated and put in a metal mortar, also heated over a fire, and well pounded with a heated metal pestle; when it is well pounded, make an ingot of it, by putting it on the fire in a mould made of iron plate, in which mould the composition must be well stirred and let to cool; then it is fit for use. To apply the composition, first tin the utensil or vessel with grain-tin and sal ammoniac, as is usually done in the common way of tinning; clean well the tinned part of the metal utensil or vessel, and then apply a coat of the composition with sal ammoniac, as is usually done in the common way of tinning; and when the composition is well spread, let it cool; then make it a little red-hot in all its parts, to neal it, and plunge the metal utensil or vessel, while yet hot, in cold water; then, with a sharp scraper, scrape and rub off the rough or grumous particles of the composition applied on the metal utensil or vessel, and scour it well with sand. The same operation must be re-

 peated

peated for every coat of the compofition that is applied; two coats of the compofition are quite fufficient for culinary utenfils or veffels, and a thin coat of grain-tin may be applied over the laft coat of the compofition, to fmooth it. The author adds, that his compofition may be employed for covering or plating the furface of all materials made of copper, brafs, iron, and other metals or mixtures of metals, and that it fhould be applied with a charcoal fire in preference to any other fire. All this may be true, and it may be a very valuable coating to copper; but the fcarcity, high price, and infufibility of platinum, muft for ever prevent it from coming into very general ufe.—We think that even the *Enamelling of Veffels for the Kitchen* muft be more common. See that article in this *Supplement.*

The following procefs is lefs expenfive, whilft the coating given by it is exceedingly durable, adds ftrength to the copper veffel, and fecures it much longer than the common tinning from the action of acids:

When the veffel has been prepared and cleaned in the ufual manner, it muft be roughened on the infide by being beat on a rough anvil, in order that the tinning may hold better, and be more intimately connected with the copper. The procefs of tinning muft then be begun with perfectly pure grained tin, having an addition of fal ammoniac inftead of the common colophonium or refin. Over this tinning, which muft cover the copper in an even and uniform manner throughout, a fecond harder coat muft be applied, as the firft forms only a kind of medium for connecting the fecond with the copper. For this fecond tinning you employ pure grained-tin mixed with zinc in the proportion of two to three, which muft be applied alfo with fal ammoniac, fmooth and even, fo that the lower ftratum may be entirely covered with it. This coating, which, by the addition of the zinc, becomes pretty hard and folid, is then to be hammered with a fmoothing hammer, after it has been properly rubbed and fcoured with chalk and water; by which means it becomes more folid and acquires a fmooth compact furface.

Veffels and utenfils may be tinned in this manner on both fides. In this cafe, after being expofed to a fufficient heat, they muft be dipped in the fluid tin, by which means both fides will be tinned at the fame time.

As this tinning is exceedingly durable, and has a beautiful colour, which it always retains, it may be employed for various kinds of metal inftruments and veffels which it may be neceffary to fecure from ruft.

TINPLATE, called in Scotland *White iron*, is a thin plate of iron covered with tin, to which it is united by chemical affinity. See Chemistry, n° 122. *Suppl.*

TIPRA, the name of certain mountainous diftricts to the eaftward of Bengal, inhabited by a people of very fingular manners. As every thing which contributes a fingle fact to the hiftory of human nature is interefting to the philofopher, the reader will be pleafed with the following account of the religion, laws, and manners of thefe people, taken from the 2d volume of the *Afiatic Refearches.*

Though they acknowledge one Creator of the univerfe, to whom they give the name of Pa'tiyan, they believe that a deity exifts in every tree, that the fun and moon are gods, and that whenever they worfhip thofe fubordinate divinities Pátiyan is pleafed. This is very fimilar to the religious creed of ancient Greece and Rome, differing only with refpect to creation, which, in the proper fenfe of the word, the Greeks and Romans feem not to have admitted.

If any one of thefe mountaineers, called in the memoir Cucis, put another to death, the chief of the tribe, or other perfons who bear no relation to the deceafed, have no concern in punifhing the murderer; but if the murdered perfon have a brother or other heir, he may take blood for blood; nor has any man whatever a right to prevent or oppofe fuch retaliation.

When a man is detected in the commiffion of theft or other atrocious offence, the chieftain caufes a recompence to be given to the complainant, and reconciles both parties; but the chief himfelf receives a cuftomary fine, and each party gives a feaft of pork or other meat to the people of his refpective tribe.

In ancient times, it was not a cuftom among them to cut off the heads of the women whom they found in the habitations of their enemies; but it happened once that a woman afked another, why fhe came fo late to her bufinefs of fowing grain? fhe anfwered, that her hufband was gone to battle, and that the neceffity of preparing food and other things for him had occafioned her delay. This anfwer was overheard by a man at enmity with her hufband; and he was filled with refentment againft her, confidering, that as fhe had prepared food for her hufband for the purpofe of fending him to battle againft his tribe, fo, in general, if women were not to remain at home, their hufbands could not be fupplied with provifion, and confequently could not make war with advantage. From that time it became a conftant practice to cut off the heads of the enemy's women, efpecially if they happen to be pregnant, and therefore confined to their houfes; and this barbarity is carried fo far, that if a Cuci affail the houfe of an enemy, and kill a woman with child, fo that he may bring two heads, he acquires honour and celebrity in his tribe, as the deftroyer of two foes at once.

As to the marriages of this wild nation, when a rich man has made a contract of marriage, he gives four or five head of *gayáls* (the cattle of the mountains) to the father and mother of the bride, whom he carries to his own houfe: Her parents then kill the *gayáls;* and having prepared fermented liquors and boiled rice with other eatables, invite the father, mother, brethren, and kindred of the bridegroom to a nuptial entertainment. When a man of fmall property is inclined to marry, and a mutual agreement is made, a fimilar method is followed in a lower degree; and a man may marry any woman except his own mother. If a married couple live cordially together, and have a fon, the wife is fixed and irremovable; but if they have no fon, and efpecially if they live together on bad terms, the hufband may divorce his wife, and marry another woman.

They have no idea of heaven or hell, the reward of good, or the punifhment of bad, actions; but they profefs a belief, that when a perfon dies, a certain fpirit comes and feizes his foul, which he carries away; and that whatever the fpirit promifes to give at the inftant when the body dies, will be found and enjoyed by the dead; but that if any one fhould take up the corfe and carry it off, he would not find the treafure.

The food of this people confifts of elephants, hogs, deer,

deer, and other animals; of which if they find the carcases or limbs in the forests, they dry them, and eat them occasionally.

When they have resolved on war, they send spies, before hostilities are begun, to learn the stations and strength of the enemy, and the condition of the roads; after which they march in the night, and two or three hours before daylight make a sudden assault with swords, lances, and arrows: if their enemies are compelled to abandon their station, the assailants instantly put to death all the males and females, who are left behind, and strip the houses of all their furniture; but should their adversaries, having gained intelligence of the intended assault, be resolute enough to meet them in battle, and should they find themselves overmatched, they speedily retreat and quietly return to their own habitations. If at any time they see a star very near the moon, they say, "to-night we shall undoubtedly be attacked by some enemy;" and they pass that night under arms with extreme vigilance. They often lie in ambush in a forest near the path, where their foes are used to pass and repass, waiting for the enemy with different sorts of weapons, and killing every man or woman who happens to pass by: in this situation, if a leech, or a worm, or a snake, should bite one of them, he bears the pain in perfect silence; and whoever can bring home the head of an enemy, which he has cut off, is sure to be distinguished and exalted in his nation. When two hostile tribes appear to have equal force in battle, and neither has hopes of putting the other to flight, they make a signal of pacific intentions, and, sending agents reciprocally, soon conclude a treaty; after which they kill several head of *gayáls*, and feast on their flesh, calling on the sun and moon to bear witness of the pacification: but if one side, unable to resist the enemy, be thrown into disorder, the vanquished tribe is considered as tributary to the victors; who every year receive from them a certain number of *gayáls*, wooden dishes, weapons, and other acknowledgments of vassalage. Before they go to battle, they put a quantity of roasted *álus* (esculent roots like potatoes), and paste of rice-flour, into the hollow of bamboos, and add to them a provision of dry rice with some leathern bags full of liquor: then they assemble, and march with such celerity, that in one day they perform a journey ordinarily made by letter-carriers in three or four days, since they have not the trouble and delay of dressing victuals. When they reach the place to be attacked, they surround it in the night, and at early dawn enter it, putting to death both young and old, women and children, except such as they choose to bring away captive: they put the heads, which they cut off, into leathern bags; and if the blood of their enemies be on their hands, they take care not to wash it off. When after this slaughter they take their own food, they thrust a part of what they eat into the mouths of the heads which they have brought away, saying to each of them, "Eat, quench thy thirst, and satisfy thy appetite; as thou hast been slain by my hand, so may thy kinsmen be slain by my kinsmen!" During their journey, they have usually two such meals; and every watch, or two watches, they send intelligence of their proceedings to their families. When any one of them sends word that he has cut off the head of an enemy, the people of his family, whatever be their age or sex, express great delight, making caps and ornaments of red and black ropes; then filling some large vessels with fermented liquors, and decking themselves with all the trinkets they possess, they go forth to meet the conqueror, blowing large shells, and striking plates of metal, with other rude instruments of music. When both parties are met, they shew extravagant joy, men and women dancing and singing together; and if a married man has brought an enemy's head, his wife wears a head dress with gay ornaments, the husband and wife alternately pour fermented liquor into each other's mouths, and she washes his bloody hands with the same liquor which they are drinking. Thus they go revelling, with excessive merriment, to their place of abode; and having piled up the heads of their enemies in the court-yard of their chieftain's house, they sing and dance round the pile; after which they kill some *gayáls* and hogs with their spears; and having boiled the flesh, make a feast on it, and drink the fermented liquor. The richer men of this race fasten the heads of their foes on a bamboo, and fix it on the graves of their parents, by which act they acquire great reputation. He who brings back the head of a slaughtered enemy, receives presents from the wealthy of cattle and spirituous liquors; and if any captives are brought alive, it is the prerogative of those chieftains, who were not in the campaign, to strike off the heads of the captives. Their weapons are made by particular tribes; for some of them are unable to fabricate instruments of war.

In regard to their civil institutions; the whole management of their household affairs belongs to the women; while the men are employed in clearing forests, building huts, cultivating land, making war, or hunting game and wild beasts. Five days (they never reckon by months or years) after the birth of a male child, and three days after that of a female, they entertain their family and kinsmen with boiled rice and fermented liquor; and the parents of the child partake of the feast. They begin the ceremony with fixing a pole in the court-yard; and then killing a *gayál* or a hog with a lance, they consecrate it to their deity; after which all the party eat the flesh and drink liquor, closing the day with a dance and with songs. If any one among them be so deformed, by nature or by accident, as to be unfit for the propagation of his species, he gives up all thought of keeping house, and begs for his subsistence, like a religious mendicant, from door to door, continually dancing and singing. When such a person goes to the house of a rich and liberal man, the owner of the house usually strings together a number of red and white stones, and fixes one end of the string on a long cane, so that the other end may hang down to the ground; then, paying a kind of superstitious homage to the pebbles, he gives alms to the beggar; after which he kills a *gayál* and a hog, and some other quadrupeds, and invites his tribe to a feast: the giver of such an entertainment acquires extraordinary fame in the nation, and all unite in applauding him with every token of honour and reverence.

When a *Cúci* dies, all his kinsmen join in killing a hog and a *gayál*; and, having boiled the meat, pour some liquor into the mouth of the deceased, round whose body they twist a piece of cloth by way of shroud: all of them taste the same liquor as an offering to his soul; and this ceremony they repeat at intervals for several days.

Tirefias, Tifri.

days. Then they lay the body on a ftage, and kindling a fire under it, pierce it with a fpit and dry it; when it is perfectly dried, they cover it with two or three folds of cloth, and enclofing it in a little cafe within a cheft, bury it under ground. All the fruits and flowers that they gather within a year after the burial they fcatter on the grave of the deceafed: but fome bury their dead in a different manner; covering them firft with a fhroud, then with a mat of woven reeds, and hanging them on a high tree. Some, when the flefh is decayed, wafh the bones, and keep them dry in a bowl, which they open on every fudden emergence; and, fancying themfelves at a confultation with the bones, purfue whatever meafures they think proper; alleging that they act by the command of their departed parents and kindfmen. A widow is obliged to remain a whole year near the grave of her hufband; where her family bring her food: if fhe die within the year, they mourn for her; if fhe live, they carry her back to her houfe, where all her relations are entertained with the ufual feaft of the *Cücis*.

If the deceafed leave three fons, the eldeft and the youngeft fhare all his property; but the middle fon takes nothing: if he have no fons, his eftate goes to his brothers; and if he have no brothers, it efcheats to the chief of the tribe.

TIRESIAS, a famous foothfayer of antiquity, was the fon of Everes and the nymph Chariclo. Pherecydes fays, that Minerva being accidentally feen by Tirefias, as fhe was bathing with Chariclo in the fountain of Hippocrene, the goddefs was enraged, and declared that he fhould fee nothing more: on which he inftantly loft his fight; but afterwards received from the goddefs fuperior endowments. Others fay, that Juno ftruck him ftone-blind for deciding a cafe between Jupiter and her, to her diffatisfaction; for which Jupiter gave him the faculty of divination: He was the moft celebrated prophet in the Grecian annals. Ulyffes is ordered by Circe to confult him in the fhades.

> There feek the Theban bard depriv'd of fight,
> Within irradiate with prophetic light.

But, befides the honour done to him by Homer, Sophocles makes him act a venerable and capital part in his tragedy of Oedipus. Callimachus afcribes to Minerva the gift of his fuperior endowments; the preeminence of his knowledge is likewife mentioned by Tully in his firft book of Divination. And not only Tirefias is celebrated by Diodorus Siculus, but his daughter Daphne, who, like her father, was gifted with a prophetic fpirit, and was appointed prieftefs at Delphos. She wrote many oracles in verfe, from whence Homer was reported to have taken feveral lines, which he interwove in his poems. As fhe was often feized with a divine fury, fhe acquired the title of *fibyl*, which fignifies "enthufiaft." She is the firft on whom it was beftowed: in aftertimes this denomination was given to feveral other females that were fuppofed to be infpired, and who uttered and wrote their predictions in verfe; which verfe being fung, their function may be juftly faid to unite the priefthood with prophecy, poetry, and mufic.

TISRI, or Tizri, in chronology, the firft Hebrew month of the civil year, and the 7th of the ecclefiaftical or facred year. It anfwered to part of our September and October.

Tithing-Men || Tombuctoo.

TITHING-Men, are now a kind of petty conftables, elected by parifhes, and fworn in their offices in the court leet, and fometimes by juftices of the peace, &c. There is frequently a tithing-man in the fame town with a conftable, who is, as it were, a deputy to execute the office in the conftable's abfence; but there are fome things which a conftable has power to do, that tithing-men and head-boroughs cannot intermeddle with. When there is no conftable of a parifh, his office and the authority of a tithing-man feems to be all one under another name.

TITHONUS, in fabulous hiftory, the fon of Laomedon king of Troy, and the brother of Priamus; was beloved by Aurora, who carried him to Delos, thence to Ethiopia, and at laft to heaven, where fhe prevailed on the Deftinies to beftow upon him the gift of immortality; but forgot to add that of youth, which could only render the prefent valuable. At length Tithonus grew fo old that he was obliged to be rocked to fleep like an infant; when Aurora, not being able to put an end to his mifery by death, transformed him into a grafshopper; which renews its youth by cafting his fkin, and in its chirping retains the loquacity of old age.

TITLE for orders, in the church of England, is an affurance of being employed and maintained as an officiating clergyman in fome cathedral or parochial church, or other place of Divine worfhip. And, by the 33*d Canon*, "no one is to be ordained but in order to be a curate or incumbent, or to have fome minifter's place in fome church, or except he be fellow, conduct, or chaplain, in fome college in one of the univerfities, or be mafter of arts of five years ftanding, and live there at his own coft." By the fame canon, the bifhop, who ordains a clerk without title, is bound to keep him till he prefer him to fome ecclefiaftical living.

TOD of wool, is mentioned in the ftatute 12 Carol. II. c. 32. as a weight containing 2 ftone, or 28 pounds.

TOMBUCTOO, a large city in North Africa, and capital of a kingdom of the fame name. It has for fome years paft been the great object of European refearch, being one of the principal marts for that extenfive commerce which the Moors carry on with the Negroes. The hopes of acquiring wealth in this purfuit, and zeal for propagating their religion, have filled this extenfive city with Moors and Mahomedan converts; the king himfelf, and all the chief officers of ftate are Moors; and they are faid to be more fevere and intolerant in their principles than any other of the Moorifh tribes in this part of Africa. Mr Park was informed, by a venerable old Negro, that when he firft vifited Tombuctoo, he took up his lodging at a fort of public inn, the landlord of which, when he conducted him into his hut, fpread a mat on the floor, and laid a rope upon it; faying, "if you are a Muffulman, you are my friend, fit down; but if you are a Kafir, you are my flave; and with this rope I will lead you to market." The reigning fovereign of Tombuctoo, when Mr Park was in Africa, was named *Abu Abrahima*. He was reported to poffefs immenfe riches, and his wives and concubines were faid to be clothed in filk, and the chief officers of ftate live in confiderable fplendour. The whole expence of his government is defrayed by a tax upon merchandize, which is collected at the gates of the city.

Of

Of that city very little is known with accuracy, as it has never been visited by any European. It is the largest on the Niger, Houssa only excepted; and probably contains from 60,000 to 80,000 inhabitants. In some of the Gazetteers, its houses are said to be built in the form of bells; but they are probably such buildings as those of Sego, which see in this *Supplement*. Tombuctoo, according to Major Rennel, is in 16° 30′ N. Lat. and 1° 33′ E. Long. from Greenwich.

TOMSOOK, in the language of Bengal, a bond.

TOOTH-ache, a well known excruciating pain (see *Encycl.*), for the alleviation, and even the cure of which, many specifics have been offered to the public. Of one of the most extraordinary of these, there is an account, in a small work published at Florence in 1794, by professor Gerbi, who gives the description of an insect, a kind of *curculio*, which, from its property of allaying the tooth-ache, has received the epithet of *antiodontalgicus*, and which is found on a species of thistle, *carduus spinosissimus*. The flowers of this thistle, when analysed, gave the acid of galls, the muriatic acid, oxalat of lime, extractive matter, and a very little resin. On the bottom of the calyx, which supports the flowers, there are often found excrescences like the gall nut, which are at first spheroidal, afterwards cylindric, and at length assume the figure of two hemispheres: they consist of the like component parts with the flowers, but contain more resin, and far more oxalat of lime; as the gall apple of the oak, according to the experiments of M. Branchi, which are here mentioned, contains more of the acid of galls than the bark and other parts of the oak, in which he could discover no sulphuric acid. The insect, according to the author's observations, eats not only the parenchyma, but also the vessels and fibres of the leaves. The egg, before the worm makes its appearance, is nourished by the sap of the plant, and of the above excrescences, in which it resides, by means of the attractive power that the egg possesses for certain vegetable juices and substances. The excrescences arise by the accumulation of a solid substance, which is precipitated from the nourishing juices of the thistle, diminished by nourishing the egg and the worm. This insect, the eggs of which are deposited in these excrescences, is, together with the *curculio* of the centuary, a new species. It is of a longish figure; covered below with short yellow hair, and above with golden yellow velvety spots. Its corslet is variegated with specks; and the covering of its wings with specks and stripes. It has a short proboscis, and shews some likeness to the *curculio villosus* of Geoffroy. Its larva represents a sort of ichneumon. By chemical analysis it exhibits some traces of common salt; by distillation with a strong dry heat, some volatile lixivious salts; and it contains, besides these, some gelatinous, and a little sebaceous and slimy extractive matter. If about a dozen or fifteen of these insects, when in the state of larva, or even when come to perfection, be bruised and rubbed slowly between the fore-finger and the thumb, until they have lost their moisture, and if the painful tooth, where it is hollow, be touched with that finger, the pain ceases, sometimes instantaneously. This power or property the finger will retain for a year, even though it be often washed and used. A piece of shamoy leather will serve equally well with the finger. Of 629 experiments, 401 were attended with complete success. In two of these cases, the hollow teeth arose from some fault in the juices: in the rest they were merely local. If the gums are inflamed, the remedy is of no avail.

To the truth of this tale the reader will give what credit he pleases; but it is surely very difficult to believe, that a living finger, continually perspiring, can retain for a year the moisture imbibed from this insect. But it seems there are other insects which have the property of curing the tooth ache; such as the *carabus chrysocephalus* of Rossi; the *carabus ferrugineus* of Fabricius; the *coccinella septem punctata* (the lady bird); the *chrysomela populi*, and the *chrysomela sanguinolenta*. It would appear, therefore, that this property belongs to various kinds of the *coleoptera*.

The idea of these insects being endowed with the property of curing the tooth-ache is not confined to Italy; for Dr Hirsch, dentist to the court of Weimar, asserts (*Verkundiger*, September 24, 1798) that he employed them with the happiest effect, except in some cases where his patients were females. He says, that he took that small insect, found commonly among corn, *coccinella septem punctata*, and bruised it between his fingers. He then rubbed the fingers with which he had bruised it, till they became warm at the points, and touched with them the unsound parts of the gums, as well as the diseased tooth. Dr Hirsch adds, that he made the same experiment a few days after with equal success, though he had not bruised a new insect with his fingers. He seems to think that, to insure the efficacy of the process, the insect should be alive; because, when dead, its internal parts, in which he presumes the virtue chiefly resides, become dried up, leaving only the wings and an empty shell; and therefore proposes to physicians to turn their attention to the finding out of some method for preserving the virtue of the insect, so that its efficacy may be in full vigour throughout the year.

Besides these beetles, charcoal has been recommended as an anodyne in the tooth-ache; but whether it operates merely by filling the hollow of the tooth, and thereby preventing the access of atmospheric air to the nerve, or by any of its singular and hitherto unknown qualities, seems not to have been well ascertained.

TOR, a town of Asia, in Arabia Petræa, seated on the Red Sea, with a good harbour, defended by a castle. There is a handsome Greek convent, in whose garden are fountains of bitter water, which they pretend are those rendered sweet by Moses, by throwing a piece of wood into them. Some think that this town is the ancient Elana. E. Long. 31. 25. N. Lat. 28. 0.

TORELLI (Joseph), was born at Verona on the 4th of November 1721. His father Lucas Torelli, who was a merchant, dying when young Torelli was but an infant, he was left entirely to the care of his mother Antonia Albertini, a Venetian lady of an excellent character. After receiving the first rudiments of learning, he was placed under the Ballerini, who, observing the genius of the boy, prevailed upon his mother to send him to complete his education at Patavia. Here he spent four years entirely devoted to study, all his other passions being absorbed by his thirst for knowledge.

The unsullied innocence of his life, and the prudence and gravity of his conduct, soon attracting the attention of his masters, they not only commended him with eagerness, but performed to him the part of parents,

conversed

Torelli. conversed with him familiarly about their respective sciences, and read over to him privately the lectures which they had to deliver. This was the case particularly with Hercules Dondinus, under whom Torelli studied jurisprudence. But he by no means confined himself to that science alone. The knowledge which he acquired was so general, that upon whatever subject the conversation happened to turn, he delivered his sentiments upon it in such a manner that one would have thought he had bestowed upon it his whole attention.

After receiving the degree of Doctor, he returned home to the enjoyment of a considerable fortune; which putting it into his power to choose his own mode of living, he determined to devote himself entirely to literary pursuits. He resolved, however, not to cultivate one particular branch to the exclusion of every other, but to make himself master of one thing after another, as his humour inclined him; and he was particularly attentive to lay an accurate and solid foundation. Tho' he declined practising as a lawyer, he did not, on that account, relinquish the study of law. The Hebrew, Greek, Latin, and Italian languages, occupied much of his time. His object was to understand accurately the two first, and to be able to write and speak the two last with propriety and elegance. Besides these languages, he learned French, Spanish, and English. On the last, in particular, he bestowed uncommon pains; for he was peculiarly attached to the British nation, and to British writers, whom he perused with the greatest attention; not merely to acquire the language, but to imbibe also that force and loftiness of sentiment for which they are so remarkable. Nay, he even began an Italian translation of Paradise Lost.

He likewise made himself acquainted with ethics, metaphysics, and polemical divinity; to which last subject he was induced to pay attention by the custom of his country. With ancient history he was very familiarly acquainted, calling in to his assistance, while engaged in that study, the aids of chronology, geography, and criticism. This last art, indeed, by means of which what is counterfeit may be distinguished from what is genuine, what is interpolated from what is uncorrupted, and what is excellent from what is faulty, he carried about with him as his counsellor and his guide upon all occasions.

The theory of *music* he studied with attention, preferring those powerful airs which make their way into the soul, and rouse the passions at the pleasure of the musician. His knowledge of *pictures* was held in high estimation by the artists themselves, who were accustomed to ask his opinion concerning the fidelity of the design, the harmony of colours, the value of the picture, and the name of the painter. He himself had a collection, not remarkably splendid indeed, but exceedingly well chosen. *Architecture* he studied with still greater attention, because he considered it as of more real utility. Nor did he neglect the pursuits of the *antiquarian*, but made himself familiarly acquainted with coins, gems, medals, engravings, antique vessels, and monuments. Indeed scarce any monumental inscriptions were engraved at Verona which he had not either composed or corrected. With the *antiquities* of his own country he was so intimately acquainted, that every person of eminence, who visited Verona, took care to have him in their company when they examined the curiosities of the city.

But these pursuits he considered merely as amusements; mathematics and the belles lettres were his serious studies. These studies are, in general, considered as incompatible; but Torelli was one of the few who could combine the gravity of the mathematician with the amenity of the muses and graces, and who handle the compass and the plectrum with equal skill. Of his progress in mathematics, several of his treatises, and especially his edition of Archimedes, published since his death by the university of Oxford, are sufficient proofs. Nor was his progress in the more pleasing parts of literature less distinguished. In both these studies he was partial to the ancients, and was particularly hostile to the poetry and the literary innovations of the French.

Nothing could be purer or more elegant than his Latin style, which he had acquired at the expence of much time and labour. His Latin translation of Archimedes is a sufficient proof of this, and is indeed really wonderful, if we consider that the Romans, being far inferior to the Greeks in mathematical knowledge, their language was of necessity destitute of many necessary words and phrases. He wrote the Italian language with the classic elegance of the 14th and 15th centuries. Witness his different works in that language, both in prose and verse. He translated the whole of Æsop's Fables into Latin, and Theocritus, the *Epithalamium* of Catullus, and the *comedy* of Plautus, called *Pseudolus*, into Italian verse. The two first books of the Æneid were also translated by him with such exactness, and so much in the style of the original, that they may well pass for the work of Virgil himself.

His life, like his studies, was drawn after the model of the ancient sages. Frugal, temperate, modest, he exhibited a striking contrast to the luxurious manners of his age. In religion he adhered strictly, though not superstitiously, to the opinions of his ancestors. He was firm to his resolutions, but not foolishly obstinate; and so strict an observer of equity, that his probity would have remained inviolate, even though there had been no law to bind him to justice. He never married, that he might have leisure to devote himself, with less interruption, to his favourite studies. Every one readily found admission to him, and no man left him without being both pleased and instructed; such was the sweetness of his temper, and the readiness with which he communicated information. He adhered with great constancy to his friendships. This was particularly exemplified in the case of Clemens Sibiliatus, who has favoured the world with the life of Torelli. With him he kept up the closest connection from a school-boy till the day of his death. He was peculiarly attached likewise to many men of distinction, both in Italy and Britain. He died in August 1781, in the 70th year of his age.

The following is a complete list of his works, his edition of Archimedes excepted, which was not published till after his death:

1. "Lucubratio Academica, sivi Somnium Jacobi Pindemontii, &c." Patavii, 1743.—2. "Animadversiones in Hebraicum Exodi Librum et in Græcum lxx Interpretationem;" Veronæ, 1744.—3. "De principe Gulæ incommodo, ejusque remedio, Libri duo;" Coloniæ

Torpedo. niæ Agrippinæ, 1744.—4. "De Probabili Vitæ Morumque Regula;" Coloniæ, 1747. 5. "Li due primi Canti dell' Iliade (di Scipione Maffei) e li due primi dell' Eneide di Giuseppe Torelli tradotti in verſi Italiani;" Verona, 1749.—6. "Gli ſteſſi due canti dell' Eneide riſtampati ſoli lo ſteſſo anno per lo ſteſſo Ramanzini."—7. "Scala de Meriti a capo d'anno Trattato Geometrico;" Verona. 1751.—8. "De Nihilo Geometrico, lib. 2.;" Verone, 1758.—9. "Lettera intorno a due paſſi del Purgatorio di Dante Alighiero;" *ib.* 1760.—10. "Della Denominazione del corrente anno vulgarmente detto 1760 in Bologna per Lelio della Volpe."—11. "Il pſeudolo. Comedia, &c. e ſi aggiunge la traduzione d'alcuni Idilli di Teocrito e di Moſco;" Firenzi, 1765.—12. "Inno a Maria Virgine nella Feſtivita della ſua Concezione;" Verona, 1766.—13. "Lettera a Miladi Vaing-Rveit premeiſſa al libro che ha per titalo xii. lettere Ingleſi, con altra lettera all'autore della ſuddetta;" Verona, 1767.—14. "Elegia di Tommaſo Gray, Poeta Ingleſe, in un Cimetero Campeſtre in verſi Italiani rimati;" Verona, 1767.—15. "Geometrica;" Veronæ. 1769.—16. "Demonſtratio antiqui Theorematis de motuum commixtione;" Veronæ, 1774.—17. "Lettera ſupra Dante contro il Signor di Voltaire;" Verona, 1781.—18. "Poemetto di Catullo ſu le Nozze di Peleo e Tetite, ed un Epitalamio dello ſteſſo;" 1781.—19. "Œſopi Fabulæ."—20. "Teocrito tradotto, in verſi Toſcani."—21. "Elementi d'Euclide tradotti nell idioma Italiano."—22. "Elementorum Proſpectivæ, libri duo."

TORPEDO, or Cramp fish, has been deſcribed under the generic title Raja; and an attempt made to explain its electrical phenomena in the article Electricity, n° 258, &c. (Both theſe articles are in the *Encyclopædia*). From ſome late diſcoveries, however, of Volta and others, the ſhock given by the torpedo appears much more analogous to the ſhock of Galvanism than to that of common electricity; and even the electrical organs of the fiſh ſeem to reſemble the apparatus with which thoſe diſcoveries in galvaniſm were made.

In the 63d volume of the Philoſophical Tranſactions, Mr Hunter deſcribes the electric organ of the torpedo as conſiſting of a number of columns, varying in their length from an inch and a half to a quarter of an inch, with diameters about two-tenths of an inch. The number of columns in each organ of the torpedo which he preſented to the Royal Society was about 470; but in a very large torpedo which he diſſected, the number of columns in one organ was 1182. Theſe columns were compoſed of films parallel to the baſe of each; and the diſtance between each partition of the columns was $\frac{1}{150}$th of an inch. From theſe facts, the reader will find the anomalies of torpedinal electricity (ſuppoſing it the ſame with common electricity) accounted for in a very ingenious and philoſophical manner by Mr Nicholſon, at p. 358 of the firſt volume of his valuable Journal. We paſs on, however, to point out the reſemblance between it and the lately diſcovered phenomena in galvaniſm.

Take any number of plates of copper, or, which is better, of ſilver, and an equal number of tin, or, which is much better, of zinc, and a like number of diſcs, or pieces of card, or leather, or cloth (A), or any porous ſubſtance capable of retaining moiſture. Let theſe laſt be ſoaked in pure water, or, which is better, ſalt and water, or alkaline leys. The ſilver or copper may be pieces of money. Build up a pile of theſe pieces; namely, a piece of ſilver, a piece of zinc, and a piece of wet card: then another piece of ſilver, a piece of zinc, and a piece of wet card: and ſo forth, in the ſame order (or any other order, provided the pieces ſucceed each other in their turn), till the whole number intended to be made uſe of is builded up. The inſtrument is then completed.

In this ſtate it will afford a perpetual current of the galvanic influence through any conductor communicating between its upper and lower plates; and if this conductor be an animal, it will receive an electrical ſhock as often as the touch is made, by which the circuit is completed. Thus if one hand be applied to the lower plate, and the other to the upper, the operator will receive a ſhock, and that as often as he pleaſes to lift his finger and put it down again.

This ſhock reſembles the weak charge of a battery of immenſe ſurface; and its intenſity is ſo low that it cannot make its way through the dry ſkin. It is therefore neceſſary that a large ſurface of each hand ſhould be well wetted, and a piece of metal be graſped in each, in order to make the touch; or elſe that the two extremities of the pile ſhould communicate with ſeparate veſſels of water, in which the hands may be plunged.

The commotion is ſtronger the more numerous the pieces. Twenty pieces will give a ſhock in the arms, if the above precautions be attended to. One hundred pieces may be felt to the ſhoulders. The current acts on the animal ſyſtem while the circuit is complete, as well as during the inſtant of commotion, and the action is abominably painful at any place where the ſkin is broken.

It is eſſential to the ſucceſs of the experiment, that the contiguous ſurfaces of the metallic plates be perfectly dry during its whole continuance; for the introduction of water or any liquid immediately deſtroys the energy of the pile. It is neceſſary that one of the metals employed ſhould be much more eaſily oxidated than the other, and that the liquid with which the card or cloth is moiſtened ſhould be capable of oxidating it. Hence when zinc and ſilver are uſed, the pile does not act if the cloth be moiſtened with newly boiled diſtilled water; and it ſoon ceaſes to act if it be covered with a receiver and ſeparated from the external air.

The Galvanic pile not only gives ſhocks to animal bodies, but it exhibits all the phenomena of common electricity. A viſible ſpark is emitted on completing the broken circle, metals are eaſily made red hot and ſet on fire by it; and Van Marum aſcertained that it charges a battery, however large, to its own intenſity in an inſtant. Now, as it poſſeſſes exactly the properties of electricity and no other properties, it can ſcarcely be doubted that the fluid which circulates in the Galvanic pile is common electricity. To explain the cauſe of the current

(A) Woollen or linen cloth appears to be more durable, and more ſpeedily ſoaked, than card.

current indeed may be a difficult taſk: and hitherto it muſt be acknowledged, that no explanation has been offered that is perfectly ſatisfactory. But this is no reaſon for denying the identity of Galvaniſm and electricity; and accordingly, this identity ſeems now admitted by all thoſe philoſophers who have given themſelves the trouble to repeat the experiments.

Though Mr Volta's celebrated experiments have not removed all uncertainty, and though he has drawn his conſequences too far, they muſt certainly be conſidered as a very important ſtep towards a theory of the Galvanic pile. Theſe experiments are in ſubſtance as follows: If two different metals, inſulated, and having only their natural quantity of electricity, are brought into contact, they aſſume, when again ſeparated, different electric ſtates; the one is poſitive and the other negative. This difference, which in each contact is very ſmall, becomes, when ſucceſſively accumulated by means of an electrical condenſer, ſufficiently ſtrong to ſeparate the electrometer very ſenſibly. The action does not take place at a diſtance, but only upon the contact of the different metals: it exiſts as long as the contact continues; but its intenſity is not the ſame for all metals. It will be ſufficient to take for example copper and zinc. In their mutual contact, the copper becomes negative and the zinc poſitive.

After having proved the developement of metallic electricity, independently of any humid conductor, Mr Volta next introduces ſuch conductors. If we form a metallic plate of two portions, the one of zinc, the other of copper, by ſoldering their ends together, and taking the zinc between our fingers, touch with the copper the upper plate of the condenſer, which is alſo of copper, the condenſer becomes negative. This agrees obviouſly with the former experiment. But if, on the contrary, we hold the copper in our fingers, and touch the upper plate of the condenſer with the zinc, upon removing the metals and raiſing the upper plate of the condenſer, it indicates no electricity, notwithſtanding the lower plate is connected with the common reſervoir in the earth. But as ſoon as we interpoſe between the zinc and the plate of the condenſer a piece of paper moiſtened with pure water, or any other moiſt conductor, the condenſer becomes charged with poſitive electricity. It becomes alſo charged, but negatively, when we hold the zinc in our fingers, and touch, with the copper, the humid conductor laid on the condenſer.

Mr Volta thus explains theſe facts—Metals, and probably all other ſubſtances, exert, as we have juſt ſeen, a reciprocal action on their reſpective electricities at the moment of contact. When we hold the metallic plate by the copper, a part of its electric fluid paſſes into the zinc; but if this zinc is in immediate contact with the condenſer, which is alſo of copper, the condenſer tends with equal force to diſcharge its own fluid into the zinc, and therefore can receive nothing from the zinc; conſequently, after the contact, it muſt remain in its natural ſtate. If, on the contrary, we place wet paper between the zinc and the copper of the condenſer, the force tending to diſplace the electricity, which exiſts only upon the contact of the two metals, is now deſtroyed; the water, which appears to poſſeſs this property, but in a very weak degree, with regard to the metallic ſubſtances, very little impedes the tranſmiſſion of the fluid of the zinc to the condenſer, and the condenſer is at liberty to become poſitively charged. Finally, when we touch the condenſer with the end which is of copper, the interpoſition of the wet paper, of which the proper action is very weak, does not prevent the tranſition of a part of the poſitive electricity of the condenſer into the plate of zinc: ſo that after ſeparation, the condenſer is found to be charged negatively.

From this theory, Mr Volta finds no difficulty in explaining the pile. For the ſake of ſimplicity, we will ſuppoſe it to be inſulated, and we will repreſent by unity the exceſs of the electricity of a piece of zinc above that of a piece of copper in immediate contact with it.

If the pile is compoſed but of two pieces, the lower one of copper, the upper one of zinc, the electric ſtate of the firſt will be repreſented by $-\frac{1}{2}$, and that of the ſecond by $+\frac{1}{2}$. If we add a third piece, which muſt be of copper, we muſt ſeparate it, in order that the fluid may be diſplaced, by wet paſteboard, from the piece of zinc below it; and in this caſe it will acquire the ſame ſtate of electricity with the zinc; at leaſt neglecting the proper action of the water, which appears to be very feeble, and alſo the ſlight degree of reſiſtance which the water may oppoſe to the communication as an imperfect conductor of electricity. The apparatus being inſulated, the exceſs of the upper piece can only be acquired at the expence of the lower piece of copper: and, in this caſe, the charges of the reſpective pieces will be different from the former experiment. The lower piece of copper will be $-\frac{2}{3}$; the piece of zinc, which is in immediate contact with it $-\frac{2}{3}+1$, or $\frac{1}{3}$; and the upper piece of copper, ſeparated from the zinc by wet paſteboard, will have the ſame charge, that is $+\frac{1}{3}$; ſo that the negative charge of the lower piece will be equal to the ſum of the poſitive charges of the two others, the whole quantity being the ſame as in the natural ſtate.

If on this pile we place another piece of zinc, this piece will demand a greater quantity of electricity by unity than the copper on which it is placed: but ſince this exceſs can only be obtained at the expence of the pieces below, the pile being inſulated, we ſhall have,

For the lower piece of copper, -1

For the ſecond piece, which is of zinc, 0

that is, it will be neutral.

For the third piece, which is of copper, ſeparated from the ſecond piece by wet paſteboard 0

For the upper piece, which is of zinc, and in contact with the third, $+1$

By purſuing the ſame mode of reaſoning, we may find the electrical ſtate of each piece of the pile, ſuppoſing it inſulated and formed of any given number of pieces; the quantities of electricity will increaſe at each ſtep, from the baſe to the ſummit of the pile, in an arithmetical progreſſion, of which the ſum will vaniſh.

Suppoſing, for the ſake of ſimplicity, the number of conſtituent parts to be even, we may diſcover, by a very eaſy calculation, that the piece of copper, which is the firſt, and the piece of zinc, which is the laſt of the pile, muſt be equally electrified, the one poſitively, the other negatively; and the ſame will be true of any pieces taken at equal diſtances from the extremities of the

the pile. Between the positive and the negative states, the electricity will vanish; and there will always be two pieces, one of zinc, the other of copper, which will be in the natural state. They will be in the middle of the pile, as has already been shown in the example of four pieces.

Let us now make a communication between the lower part of the pile and the earth: it is evident, that then the lower piece of copper, which is negatively electrified, will tend to absorb from the ground what it has lost; but its electrical state cannot change, unless that of the superior pieces be also varied, since the difference of the pieces must always be the same in the state of equilibrium. Therefore all the negative quantities of the lower half of the pile must be neutralised at the expence of the common reservoir; and in this case, the lowest piece, which is of copper, will have the electricity of the earth, which we call o. The second piece, which is of zinc, and in immediate contact with the first, will have + 1. The third, which is of copper, and separated from the zinc below it by wet pasteboard, will also have + 1. The fourth, which is of zinc, and in immediate contact with the third, will have + 2. And in the same manner the electricity of the different elements will continue to increase in arithmetical progression.

If we then touch, with our hands, the two extremities of the pile, these excesses of electricity will be discharged through our bodies into the common reservoir, and will produce a shock so much the more sensible, as the loss is quickly repaired from the earth, and an electrical current is formed, of which the rapidity is greater within the pile than within the animal body, which is an imperfect conductor; so that the internal parts of the pile are at liberty to resume a degree of tension approaching to that which they had when in the state of equilibrium. The communication with the earth being still preserved, if we bring the summit of the pile into contact with the upper plate of a condenser, of which the lower is connected with the ground, the electricity, which was accumulated at the summit with a very slight degree of tension, will pass into the condenser, where the tension may be considered as evanescent; but the pile not being insulated, this loss will be repaired from the earth: the new portions of electricity recovered by the upper part of the pile will pass into the condenser like the preceding, and will at last be so accumulated there, that when we remove the plate of the condenser, we may find in it very evident marks of electricity, and we may even take sparks from it.

Such is Mr Volta's theory; but the experiments of Mr Davy are sufficient to demonstrate that the ideas of this celebrated electrician require some modification. His theory must at least be extended to the imperfect conductors as well as the metals. Mr Davy has shewn that two kinds of galvanic circles may be formed. The first is composed of two different metallic substances, or one metallic substance and charcoal, and a peculiar fluid. The second is composed by two different fluids and one metallic substance.

The following table of some circles of the first kind, in which the different substances are arranged according to the order of their known galvanic powers, will show how intimately chemical agencies are related to the production of galvanism.

TABLE *of some Galvanic Circles. Composed of two perfect Conductors and one imperfect Conductor.*

More oxidable substances.	Less oxidable substances.	Oxidating fluids.
Zinc.	With gold, charcoal, silver, copper, tin, iron, mercury.	Solutions of nitric acid in water, of muriatic acid and sulphuric acid &c. Water holding in solution oxygen, atmospheric air, &c.
Iron.	. . . gold, charcoal, silver, copper, tin,	
Tin.	. . gold, silver, charcoal.	
Lead	. . . gold, silver.	
Cop.	. . . gold, silver.	Solution of nitrate of silver and mercury. Nitric acid, acetous acid.
Silv.	. . . gold.	Nitric acid.

The most active single circles of the second order are those in which the two imperfect conductors are capable of exerting different chemical agencies on the perfect conductor, at the same time that they are possessed of power of action on each other. But even circles in which only one of the fluid parts is decomposable by the solid, are possessed of power of action. Thus copper, silver, or lead, acts very powerfully when connected in the proper order with solutions of alkaline sulphurets and of nitrous acid; both of which fluids are possessed of distinct chemical agencies upon them. And copper or silver acts, though with less intensity, when water, or a fluid which they are incapable of decomposing, is substituted for one of the chemical agents.

The following table contains some powerful galvanic combinations of the second order, arranged according to the intensity of their action.

TABLE *of some Galvanic Circles. Composed of two imperfect Conductors and one perfect Conductor.*

Perfect conductors.	Imperfect conductors.	Imperfect conductors.
Cop. Silv. Lead Tin. Iron. Zinc.	Solutions of alkaline fulphurets, capable of acting on the first three metals but not on the last three.	Solutions of nitrous acid, oxygenated muriatic acid, &c. capable of acting on all the metals.

Messrs Nicholson and Carlisle constructed an apparatus similar to that of Volta, which gave them a shock as before described, and a very acute sensation whereever the skin was broken. Very early in the course of this experiment, the contacts being made sure by placing a drop of water upon the upper plate, Mr Carlisle observed a disengagement of gas round the touching wire. This gas, though very minute in quantity, evidently seemed to have the smell afforded by hydrogen when the wire of communication was steel. This, with some other facts, led Mr Nicholson to propose to break the circuit by the substitution of a tube of water between

tween two wires. They therefore inferted a brafs wire through each of two corks inferted in a glafs tube of half an inch internal diameter. The tube was filled with New River water, and the diftance between the points of the wires in the water was one inch and three quarters. This compound difcharger was applied fo that the external ends of its wire were in contact with the two extreme plates of a pile of 36 half crowns, with the correfpondent pieces of zinc and pafteboard. A fine ftream of minute bubbles immediately began to flow from the point of the lower wire in the tube which communicated with the filver, and the oppofite point of the upper wire became tarnifhed, firft deep orange and then black. On reverfing the tube, the gas came from the other point, which was now loweft; while the upper, in its turn, became tarnifhed and black. Reverfing the tube again, the phenomena again changed their order. In this ftate the whole was left for two hours and a half. The upper wire gradually emitted whitifh filmy clouds, which, towards the end of the procefs, became of a pea-green colour, and hung in perpendicular threads from the extreme half inch of the wire, the water being rendered femiopaque by what fell off, and in a great part lay, of a pale green on the lower furface of the tube, which, in this difpofition of the apparatus, was inclined about forty degrees to the horizon. The lower wire, of three quarters of an inch long, conftantly emitted gas, except when another circuit, or complete wire, was applied to the apparatus; during which time the emiffion of gas was fufpended. When this laft mentioned wire was removed, the gas re-appeared as before, not inftantly, but after the lapfe of four beats of a half fecond clock ftanding in the room. The product of gas, during the whole two hours and a half, was two-thirtieths of a cubic inch. It was then mixed with an equal quantity of common air, and exploded by the application of a lighted waxed thread.

Thefe experiments were immediately repeated and varied by other philofophers. Meffrs Cruickfhank, Haldane, Davy, Henry, Wollafton, Fourcroy, and Vauquelin, are the moft diftinguifhed.

Mr Cruickfhank afcertained, that when the wire coming from the zinc end of the pile is plunged into infufion of litmus, the infufion becomes red, and an acid, which appears to be the nitric, is formed; that the wire from the filver end reddens the infufion of brazil wood, and of courfe an alkali is formed. This alkali has been fuppofed to be fixed; but in our experiments it was obvioufly ammonia, for the change on the infufion of mallows (the colouring matter which we ufed) was not permanent. He afcertained alfo, that the filver end wire revives metals from their falts, as had been previoufly known to happen whenever nafcent hydrogen comes in contact with them. He thought alfo, that he had afcertained that all liquids containing no oxygen are nonconductors of galvanifm.

To avoid the trouble of conftantly repiling the pieces of filver and zinc, Mr Cruickfhank conftructed a kind of trough of baked wood, 26 inches in length. 1.7 inches deep, and 1.5 inches wide: in the fides of this trough grooves were made oppofite to each other, about the tenth of an inch in depth, and fufficiently wide to admit one of the plates of zinc and filver when foldered together; three of thefe grooves were made in the fpace of one inch and the tenths, fo that the whole machine contained 60 pair of plates. A plate of zinc and filver, each 1.6 inches fquare, well cemented together, were introduced into each of thefe grooves or notches, and afterwards cemented into the trough by a compofition of rofin and wax, fo perfectly that no water could pafs from one cell to the other, nor between the plates of zinc and filver. This circumftance muft be ftrictly attended to, elfe the machine will be extremely imperfect. When all the plates were thus fecured in the trough, the interftices or cells formed by the different pairs of plates were filled with a folution of the muriat of ammonia, which here fupplied the place of the moiftened papers in the pile, but anfwered the purpofe much better. It is hardly neceffary to obferve, that in fixing the zinc and filver plates, they muft be placed regularly, as in the pile, *viz.* alternately zinc and filver, the filver plate being always on the fame fide. When a communication was made between the firft and laft cell, a ftrong fhock was felt in the arms, but fomewhat different from that given by the pile, being quicker, lefs tremulous, and bearing a greater refemblance to the common electrical fhock. He conftructed two of thefe machines, which contained in all 100 pair of plates; thefe when joined together gave a very ftrong fhock, and the fpark could be taken in the day-time at pleafure; but what furprifed him not a little, was the very flender power which they poffeffed in decompofing water: in this refpect they were certainly inferior to a pile of 30 pair, although fuch a pile would not give a fhock of one third the ftrength.

This apparatus retained its power for many days, and would in all probability have retained it much longer, had not the fluid got between the dry furfaces of the metals. To remedy this defect, he foldered the zinc and filver plates together, and found that this method anfwers very well. The zinc plates may be cleaned at any time, by filling the different cells for a few minutes with the dilute muriatic acid. Although this apparatus may not entirely fuperfede the pile, efpecially if it fhould be found to decompofe water, &c. but flowly, yet in other refpects it will no doubt be found very convenient and portable.

Colonel Haldane proved, as might have been expected, that the pile does not act under water, nor in vacuo, nor when furrounded by a gas which contains no oxygen, and found it more powerful when placed in oxygen gas.

Mr Henry found that more oxygen was obtained from fulphuric acid than from water by the agency of the pile. He deoxydated nitric and oxymuriatic acid by means of it, and obtained gafes by the decompofition of the water of liquid muriatic acid. The gafes he found incapable of tranfmitting the galvanic influence.

Mr Davy found, that if the zinc end wire be plunged into one glafs of water, and the filver end wire into another, and the circle be completed by plunging a finger into each glafs, the hydrogen gas is evolved in one glafs and the oxygen in the other. He proved that the action of the pile is proportional to the oxydation of the zinc; that its action is increafed by interpofing acids, becaufe they increafe the rapidity of oxydation, and that with acids the pile acts even in vacuo. He found alfo that a pile of zinc and charcoal has very great

great energy. To him we are indebted for the pile with one metal formerly defcribed, and he has more lately proved that charcoal or plumbago may be fubftituted for the metal. A pile of charcoal, plumbago, and cloth, moiftened with muriat of lime, retains its energy for a long time.

Dr Wollafton proved, that when common electricity is paffed through water by means of two very fine metallic points, chemical changes are effected by it, analagous to thofe occafioned by the tranfmiffion of the galvanic influence. This fact, fingly, prefents a very ftrong analogy between galvanifm and the common electrical influence; and when compared with the other facts, it amounts almoft to a demonftration of their identity. Dr Wollafton likewife afcertained that electricity is evolved during oxydation. He found that an electrical machine cannot be excited when plunged into any gas that does not contain oxygen; and fuppofes the excitation in a great meafure owing to the oxydation of the amalgam.

Fourcroy and Vauquelin made ufe of metallic plates about a foot fquare, and obferved that a much fmaller number of fuch plates than are fufficient to produce fhocks, give fparks, and even fet fire to the metals when prefented in fine wires or leaves. By twelve pairs of fuch plates, a mixture of oxygen and hydrogen gas may be exploded, and iron wire fet on fire in oxygen gas. All the metals may be fet on fire.

Such is a fhort fketch of the new facts which have been difcovered in galvanifm; but the examination of the fubject has not proceeded far enough to admit of a fatisfactory explanation of them. The facts relating to the feparate production of oxygen and hydrogen, acid and alkali, in water, are totally incommenfurable with the ufually received theory of chemiftry. And even fuppofing that the appearance of the two laft of thefe bodies is connected with the prefence of atmofpheric air, it is ftill extremely difficult to conceive, that either oxygen or hydrogen can pafs in an invifible form through fluids or organic bodies. Common phyfical facts prefent us with no analogies fufficiently diftinct to enable us to reafon on this fubject; and the elucidation of it will probably be connected with perfectly new views of corpufcular action.

If this article be thought long, and if we appear to have loft fight of our original fubject, the *Torpedo*, we have only to plead in excufe for our conduct, that whilft we could not avoid pointing out the refemblance between the fhock given by the torpedo and that by Volta's apparatus, we felt it a kind of duty to embrace the only opportunity that we fhall have of laying before our readers the additional information refpecting the phenomena of Galavnism which we have received fince the publication of that article. Thefe phenomena are yet new, and they are unqueftionably important; indeed fo very important, that to us it appears neither impoffible, nor even improbable, that to the galvanic agency of metals and minerals may be attributed volcanoes and earthquakes.

TOUCAN, or American Goose, is one of the modern conftellations of the fouthern hemifphere, confifting of nine fmall ftars.

TRACTORS, Metallic. See Perkinism in this *Suppl.*

TRACTRIX, in geometry, a curve line, called alfo Catenaria; which fee, *Encyclopædea* and Arch, *Suppl.*

TRADESCANT (John), an ingenious naturalift and antiquary, was, according to Anthony Wood, a Fleming or a Dutchman. We are informed by Parkinfon, that he had travelled into moft parts of Europe, and into Barbary; and from fome emblems remaining upon his monument in Lambeth church-yard, it plainly appears that he had vifited Greece, Egypt, and other eaftern countries. In his travels, he is fuppofed to have collected, not only plants and feeds, but moft of thofe curiofities of every fort which, after his death, were fold by his fon to the famous Elias Afhmole, and depofited in his mufeum at Oxford. When he firft fettled in this kingdom cannot, at this diftance of time, be afcertained. Perhaps it was at the latter end of the reign of Queen Elizabeth, or the beginning of that of King James I. His print, engraven by Hollar before the year 1656, which reprefents him as a perfon very far advanced in years, feems to countenance this opinion. He lived in a great houfe at South Lambeth, where his mufeum was frequently vifited by perfons of rank, who became benefactors thereto: among thefe were King Charles I. (to whom he was gardener), Henrietta Maria his Queen, Archbifhop Laud, George Duke of Buckingham, Robert and William Cecil, Earls of Salifbury, and many other perfons of diftinction. John Tradefcant may therefore be juftly confidered as the earlieft collector (in this kingdom) of every thing that was curious in natural hiftory, viz. minerals, birds, fifhes, infects, &c. He had alfo a good collection of coins and medals of all forts, befides a great variety of uncommon rarities. A catalogue of thefe, publifhed by his fon, contains an enumeration of the many plants, fhrubs, trees, &c. growing in his garden, which was pretty extenfive. Some of thefe plants are, if not totally extinct, at leaft become very uncommon, even at this time: though this able man, by his great induftry, made it manifeft, in the very infancy of botany, that there is fcarce any plant extant in the known world that will not, with proper care, thrive in this kingdom.

When his houfe at South Lambeth, then called *Tradefcant's Ark*, came into Afhmole's poffeffion, he added a noble room to it, and adorned the chimney with his arms, impaling thofe of Sir William Dugdale, whofe daughter was his third wife; where they remain to this day.

It were much to be wifhed, that the lovers of botany had vifited this once famous garden before, or at leaft in the beginning of the 17th century. But this feems to have been totally neglected till the year 1749, when Dr Watfon and the late Dr Mitchell favoured the Royal Society with the only account now extant of the remains of Tradefcant's garden.

When the death of John Tradefcant happened is not known; no mention being made thereof in the regifter-book of Lambeth church.

TRAJECTORY, a term often ufed, generally for the path of any body, moving either in a void, or in a medium that refifts its motion; or even for any curve paffing through a given number of points. Thus Newton, Princip. lib. 1. prop. 22. propofes to defcribe a trajectory that fhall pafs through five given points.

TRAITOR's

TRAITOR's ISLAND, one of the Archipelago called *NAVIGATORS Islands*, in the South Sea (See that article *Suppl.*). It is low and flat, with only a hill of some height in the middle; and is divided into two parts by a channel, of which the mouth is about 150 toises wide. It abounds with bananas, yams, and the finest cocoa-nuts, which Perouse says he ever saw. About twenty canoes approached the French ships without dread, traded with a good deal of honesty, and never refused, like the natives of the archipelago of Navigators, to give their fruit before they were paid for it; nor, like them, did they give a preference to beads over nails and pieces of iron. They spoke, however, the same language, and had the same ferocious look; their dress, their manner of tatowing, and the form of their canoes, were the same; nor could we (says the author) doubt that they were one and the same people: they differed, indeed, in having universally two joints cut off from the little finger of the left hand; whereas, in the islands of Navigators, I only perceived two individuals who had suffered that operation. They were also of much lower stature, and far less gigantic make; a difference proceeding, no doubt, from the soil of these islands, which being less fertile, is consequently less favourable to the expansion of the human frame.

TRAMMELS, in mechanics, an instrument used by artificers for drawing ovals upon boards, &c. One part of it consists of a cross with two grooves at right angles; the other is a beam carrying two pins, which slide in those grooves, and also the describing pencil. All the engines for turning ovals are constructed on the same principles with the trammels: the only difference is, that in the trammels the board is at rest, and the pencil moves upon it; in the turning engine, the tool, which supplies the place of the pencil, is at rest, and the board moves against it. See a demonstration of the chief properties of these instruments by Mr Ludlam, in the *Phil. Transf.* vol. lxx. p. 378, &c.

TRANSFORMATION, in geometry, is the changing or reducing of a figure, or of a body, into another of the same area, or the same solidity, but of a different form. As, to transform or reduce a triangle to a square, or a pyramid to a parallelopipedon.

TRANSFORMATION of Equations, in algebra, is the changing equations into others of a different form, but of equal value. This operation is often necessary, to prepare equations for a more easy solution.

TRANSLATION, in literature, is a matter of so much importance, that no other apology can be made for the very imperfect manner in which it is treated in the *Encyclopædia*, than a candid declaration that it was impossible to enter at all upon the subject within the narrow limits to which we were then restricted by the proprietors of the work. The fundamental laws of translation, which we gave in that article, we believe indeed to be incontrovertibly just; but we are sorry that our inaccurate expressions have led some of our readers to suppose that Mr Tytler, in his essay, has done nothing more than illustrate the ideas that were suggested to him by Dr Campbell. The truth is, that the same ideas of a just translation occurred to these two ingenious writers at the same time, without the smallest communication with each other; and this fact, which consists with our own knowledge, is surely a corroboration of the laws laid down by both; but the question is, how are these laws to be obeyed?

In order that a translator may be enabled to give a complete transcript of the ideas of the original work, it is almost needless to observe, that he must possess a perfect knowledge of both languages, *viz.* that of his author, and that into which he is to translate; and that he must have a competent acquaintance with the subject of which his author treats. These propositions we consider as self-evident; but if any of our readers shall be of a different opinion, we refer them to an *Essay on the Principles of Translation*, published 1797 by Cadell and Davies, London, where they will find our doctrine very clearly illustrated. It may be proper to add, that such a knowledge of the Greek and Latin languages as merely enables a man to read them with ease and entertainment to himself, is by no means sufficient to qualify him for translating every Greek and Latin book, even though it treats of a subject with which he has a general acquaintance. The religious rites and ceremonies of the Greeks and Romans, as well as the radical words of their language, were derived from the East; and he who is an absolute stranger to oriental literature, will be very liable to mistake occasionally the sense of Greek and Roman authors who treat of religious subjects. We could illustrate the truth of this position by quotations from some of the most admired modern translations of the Greek Scriptures, which we have no hesitation to say fall very short of the authorised version in accuracy as well as in elegance. The divines employed by King James to translate the Old and New Testaments were profoundly skilled in the learning, as well as in the languages, of the East; whilst some of those who have presumed to improve their version seem not to have possessed a critical knowledge of the Greek tongue, to have known still less of the Hebrew, and to have been absolute strangers to the dialect spoken in Judea in the days of our Saviour, as well as to the manners, customs, and peculiar opinions of the Jews sects. Neither metaphysical acuteness, nor the most perfect knowledge of the principles of translation in general, will enable a man who is ignorant of these things to improve the authorised version either of the Gospels or the Epistles; for such a man knows not accurately, and therefore cannot give a complete transcript of the ideas of the original work.

But supposing the translator completely qualified with respect to knowledge, it becomes a question, whether he may, in any case, add to or retrench the ideas of his author? We are strongly inclined to think, that, in no case, it is allowable to take such liberties; but the ingenious and elegant essayist, whose work on the principles of translation we must always quote with respect, is of a different opinion. "To give a general answer (says he) to this question, I would say, that this liberty may be used, but with the greatest caution. It must be further observed, that the superadded idea shall have the most necessary connection with the original thought, and actually increase its force. And, on the other hand, that whenever an idea is cut off by the translator, it must be only such as is an accessory, and not a principle, in the clause or sentence. It must likewise be confessedly redundant, so that its retrenchment shall not impair or weaken the original thought. Under these

limitations,

Tranflation.

limitations, a tranflator may exercife his judgment, and affume to himfelf, in fo far, the character of an original writer."

Of the judicious ufe, as he thinks it, of this liberty, the author quotes many examples, of which we fhall felect three, as well calculated to illuftrate our own ideas of the fubject.

In the firft book of the Iliad, Achilles, having refolved, though indignantly, to give up Brifeis, defires Patroclus to deliver her to the heralds of Agamemnon :

> Ὡς φατο· Πατροκλος δε φιλω επεπειθεθ' ἑταιρω·
> Εκ δ' αγαγε κλισιης Βρισηιδα καλλιπαρηον,
> Δωκε δ' αγειν· τω δ' αυτις ιτην παρα νηας Αχαιων·
> Ἡ δ' αεκουσ' ἁμα τοισι γυνη κιεν· *Ilias*, A. 345.

> Patroclus now th' unwilling beauty brought ;
> She in foft forrows, and in penfive thought,
> Paft filent, as the heralds held her hand,
> And oft look'd back, flow moving o'er the ftrand.
> Pope.

Our author thinks, and we heartily agree with him, that the amplification in the three laft lines of this verfion highly improves the effect of the picture ; but we cannot confider this amplification as a new idea fuperadded. It was the object of Homer to inform his countrymen, that Brifeis went with the heralds *unwillingly*. This he does by the words ἡ δ' αεκουσ' ἁμα τοισι γυνη κιεν·, and it is by no means improbable, that the rhythmical movement of the verfe may have prefented to the ancient Greeks the image of the lady walking flowly and reluctantly along. This image, we are fure, is not produced by a literal tranflation of the Greek words into Englifh ; and therefore it was Pope's duty, not to add to the ideas of the original, but, by amplification, to prefent to his own countrymen the picture which Homer, by the fuperiority of the Greek language and rhythm, had prefented to his.

In the ninth book of the Iliad, where Phœnix reminds Achilles of the care he had taken of him while an infant, one circumftance, extremely mean, and even difgufting, is found in the original :

> ———ὁτε δη σ' επ' εμοισιν εγω γουνασσι καθισσας
> Οψου τ' ασαιμι προταμων, και οινον επισχων·
> Πολλακι μοι κατεδευσας επι στηθεσσι χιτωνα,
> Οινου αποβλυζων εν νηπιεη αλεγεινη.

The literal verfion of thefe lines is indeed very grofs : "When I placed you before my knees, I crammed you with meat, and gave you wine, which you often vomited upon my bofom, and ftained my clothes, in your troublefome infancy :" but we cannot agree with our author, that the Englifh reader is obliged to Pope for having altogether funk this naufeous image. What is, or ought to be, our object in reading Homer ? If it be merely to delight our ear with fonorous lines, and pleafe our fancy with grand or fplendid images, the tranflator certainly did right in keeping out of view this difgufting picture of favage life ; but when he did fo, he cannot be faid to have given a complete tranfcript of his author's ideas. To pleafe ourfelves, however, with fplendid images, is not our only object when ftudying the works of the ancient poets. Another, and in our opinion a more important object, is to acquire a lively notion of ancient manners ; and if fo, Pope grofsly milleads the mere Englifh reader, when, inftead of the beaftly image of Homer, he prefents him with the following fcene, which he may daily meet with in his own family, or in the families of his friends :

> Thy infant breaft a like affection fhow'd,
> Still in my arms, an ever pleafing load ;
> Or at my knee, by Phœnix would'ft thou ftand,
> No food was grateful but from Phœnix hand :
> I pafs my watchings o'er thy helplefs years,
> The tender labours, the compliant cares.

This is a picture of the domeftic manners of Great Britain in the 19th century, and not of Greece in the heroic ages.

In the beginning of the eighth book of the Iliad, Homer puts into the mouth of Jove a very ftrange fpeech, ftuffed with braggart vaunting and ludicrous images. This, as our author obferves, is far beneath the dignity of the thunderer ; but it is only beneath the dignity of the thunderer as our habits and modes of thinking compel *us* to conceive fuch a being. The thunderer of the Greeks was a notorious adulterer and fodomite, whofe moral character finks beneath that of the meaneft of our bravos ; and as he had dethroned his father, and waged for fome time a doubtful war with certain *earthly* giants, it does not appear to us that the boafting fpeech which Homer puts into his mouth is at all unfuitable to his acknowledged attributes. But whether it be or not, was not the tranflator's concern. Homer, when he compofed it, certainly thought it not unworthy of the thunderer ; and whatever Pope's opinion might be, he had no right to fubftitute his own notions of propriety for thofe of his author. The mythological tales of the poets, and more efpecially of Homer and Hefiod, conftituted, as every one knows, the religious creed of the vulgar Greeks (fee Polytheism, n° 33. *Encycl.*) ; and this circumftance makes it doubly the duty of a tranflator to give, on fuch fubjects, a fair tranfcript of his author's ideas, that the mere Englifh reader, for whom he writes, may know what the ancients really thought of the objects of their idolatrous worfhip. This Pope has not done in the fpeech under confideration ; and has therefore, in our opinion, deviated widely from the firft and moft important of the three general laws of tranflation. Johnfon has apologized, we think fufficiently, for many of Pope's embellifhments of his author ; but he has not attempted to make an apology for fuch embellifhments as alter the fenfe. We cannot indeed conceive a pretence upon which it can ever be allowable in a tranflator to add to the ideas of his author, to retrench, or to vary them. If he be tranflating hiftory, and find his author advancing what he *believes* to be falfe, he may correct him in a note ; but he has no right to make one man utter, as his own, the belief or the fentiments of another, when that belief, and thofe fentiments, are *not* his own. If he be tranflating a work of fcience, he may likewife correct the errors of his author in notes, as Dr Clerke corrected thofe of Rohault ; but no man has a right to give to a Rohault the fcience of a Newton. The tranflator of a poem may certainly employ amplification to place in a ftriking light the images or the fentiments of the original work ; but he muft not alter thofe images or fentiments fo as to make that appear grand or elegant in the verfion, which is mean or difgufting in the original. On every occaſion on which he takes ſuch liberties as theſe, he ceaſes to be a tranſlator, and becomes a faithleſs paraphraſt.

The ſecond general law of tranſlation, though certainly leſs important, is perhaps more difficult to be obſerved than the firſt. We have ſtated it in theſe words: (See Translation, *Encycl.*) "The ſtyle and manner of the original ſhould be preſerved in the tranſlation;" but it is obvious, that this cannot be done by him who poſſeſſes not ſufficient taſte and judgment to aſcertain with preciſion to what claſs the ſtyle of the original belongs. "If a tranſlator fail in this diſcernment, and want this capacity, let him be ever ſo thoroughly maſter of the ſenſe of his author, he will preſent him through a diſtorting medium, or exhibit him in a garb that is unſuitable to his character." It would obviouſly be very improper to tranſlate the elegantly ſimple language of Cæſar into rounded periods like thoſe of *The Rambler*, or the Orations of Cicero into the language of Swift.

The chief characteriſtic of the hiſtorical ſtyle of the ſacred Scriptures is its ſimplicity; and that ſimplicity is, for the moſt part, well preſerved in the authoriſed verſion. It is, however, loſt in many of the modern verſions. Caſtalio's, for inſtance, though intitled to the praiſe of elegant latinity, and though, in general, faithful to the ſenſe of the original, yet exhibits numberleſs tranſgreſſions of the law which is now under conſideration. Its ſentences are formed in long and intricate periods, in which many ſeparate members are artfully combined; and we obſerve a conſtant endeavour at claſſical phraſeology and ornamented diction, inſtead of the beautiful ſimplicity of the original.

The verſion of the Scriptures by Arias Montanus is, in ſome reſpects, a contraſt to that of Caſtalio. By adopting the literal mode of tranſlation, Arias undoubtedly intended to give as faithful a picture as he could, both of the ſenſe and of the manner of the original. Not attending to the peculiar idioms of the Hebrew, Greek, and Latin tongues, which, in ſome reſpects, are very different from each other, he has, by giving to his Latin the combination and idioms of the two firſt of theſe languages, ſometimes made the ſacred writers talk abſurdly. In Latin, as every ſchool-boy knows, two negatives make an affirmative, whilſt in Greek they add force to the negation. Χωρις εμου ου δυνασθε ουδεν ſignifies, "Without me ye can do nothing," or, "Ye cannot *poſſibly* do any thing;" but Arias has tranſlated the words *ſine me non poteſtis facere nihil*, *i. e.* "without me ye cannot do nothing," or, "ye *muſt* do ſomething," which is directly contrary to the meaning of our Lord. It is not therefore by tranſlating literally or verbally that we can hope to preſerve the ſtyle and manner of the original.

To expreſs in florid or elevated language the ideas of an author who writes himſelf in a ſimple ſtyle, is not to give in the verſion a juſt picture of the original; but to attempt, for the ſake of verbal accuracy, to introduce into one language the peculiar idioms or conſtruction of another, is ſtill worſe; as in this mode of tranſlation the ſenſe, as well as the manner of the original, is loſt. The rule obviouſly is to uſe, in the verſion, the words and phraſeology which we have reaſon to believe that the author would himſelf have uſed, had he been maſter of the language into which we are tranſlating his ideas. Thus, if we are to tranſlate into Engliſh a piece of elegantly ſimple Greek or Latin, we muſt make ourſelves completely maſter of the author's meaning, and, neglecting the Greek or Latin *idioms*, expreſs that meaning in elegantly ſimple Engliſh. We need not add, that when the language of the original is florid or grand, if that ſtyle be ſuited to the ſubject, the language of the tranſlation ſhould be florid or grand likewiſe; but care muſt always be taken that perſpicuity be not ſacrificed to ambitious ornaments of any kind; for ornaments which obſcure the ſenſe are worſe than uſeleſs.

If theſe reflections be juſt, it is obvious that a poem cannot be properly tranſlated into proſe. The mere ſenſe may doubtleſs be thus transferred from one language into another, as has generally been done by Macpherſon in his hobbling verſion of the Iliad, and perhaps more completely by a late tranſlator of Anacreon; but in ſuch a verſion, the ſtyle and manner of the original muſt neceſſarily be loſt. Of this the following accurate proſe tranſlation of Anacreon's ninth ode (on a dove) is a ſtriking inſtance:

"O lovely Pigeon! whence, whence do you fly? Whence, ſpeeding through the air, do you breathe, and diſtil ſo many perfumes? Who is your maſter? For it concerns me to know. 'Anacreon ſent me to a youth, —to Bathyllus, at preſent the prince, and diſpoſing of all things. Venus ſold me, receiving a little hymn in return. And I ſerve Anacreon in ſuch tranſactions as theſe: and now I carry his letters, ſuch as you ſee: and he affirms that he will immediately make me free. But I will remain a ſervant with him although he may diſmiſs me: For wherefore does it behove me to fly, both over mountains, and fields, and to perch on trees, devouring ſome ruſtic food? Now indeed I eat bread, ſnatching it from the hands of Anacreon himſelf; and he gives to me the wine to drink which he drinks before me; and having drunk, I perhaps may dance, and cover my maſter with my wings: then going to reſt, I ſleep upon the lute itſelf. You have it all;—begone: you have made me more talkative, O mortal! than even a jay *."

How inferior is the general effect of this piece of proſe to that of the well known poetical verſions of Addiſon and Johnſon? and yet the mere *ideas* of the original are perhaps more faithfully tranſcribed by this anonymous writer than by either of thoſe elegant tranſlators. The emotions indeed excited by the original are not here brought into view.

* *The Ode of Anacre[on] tranſlated into Engli[ſh] proſe, prin[t]ed at York* 1796.

The third general law of tranſlation is ſo nearly allied to the ſecond, that we have very few directions to give for the obſervation of it. He who, in his verſion, preſerves the ſtyle and manner of the original, as we have endeavoured to ſhew that they *ought* to be preſerved, will, of courſe, give to the tranſlation the eaſe of original compoſition. The principal difficulty that he has to encounter in this part of his taſk, will occur in the tranſlating of idiomatical and proverbial phraſes. Hardly any two languages are conſtructed preciſely in the ſame way; and when the ſtructure of the Engliſh language is compared with that of the Greek and Latin, a remarkable difference between the ancient and modern tongues is found to pervade the whole. This muſt occaſion very conſiderable difficulty; but it is a difficulty which will be removed by a due obſervance of the

former

former law, which directs the translator to make his author speak English in such a style to Englishmen as he spoke his own tongue to his own countrymen, and of course to use the English idiom with English words. But what is to be done with those proverbial phrases of which every language has a large collection, and which allude to local customs and manners?

The ingenious author of the Essay so often quoted, very properly observes, in answer to this question, that the translation is perfect when the translator employs, in his own language, an idiomatic phrase corresponding to that of the original. "It is not (says he) possible perhaps to produce a happier instance of translation by corresponding idioms, than Sterne has given * in the translation of Slawkenbergius's tale. *Nihil me penitet hujus nasi*, quoth Pamphagus; that is, "My nose has been the making of me." *Nec est cur pœniteat*; that is, "How the deuce should such a nose fail?" *Miles peregrini in faciem suspexit!* "The centinel looked into the stranger's face. Never saw such a nose in his life!"

* *Tristram Shandy.*

"As there is nothing (continues our author) which so much conduces both to the ease and spirit of composition as a happy use of idiomatic phrases, there is nothing which a translator, who has a moderate command of his own language, is so apt to carry to an extreme." Of this he gives many striking examples from Echard's translations of Terence and Plautus, for which we must refer the reader to the Essay itself. He observes, likewise, that in the use of idiomatic phrases, a translator frequently forgets both the country of his original author, and the age in which he wrote; and while he makes a Greek or Roman speak French or English, he unwittingly puts into his mouth allusions to the manners of modern France or England. This, to use a phrase borrowed from painting, may be termed an offence against the *costume* The proverbial expression βατραχῳ ὑδωρ, in Theocritus, is of similar import with the English proverb, *to carry coals to Newcastle*; and the Scotch, *to drive salt to Dysart*; but it would be a gross impropriety to use either of these expressions in the translation of an ancient classic. Of such improprieties our author points out many instances both in French and English translations of the classics; and he might have increased the number by quotations from Blackwell's Memoirs of the Court of Augustus, where, instead of Roman senators and their wives, we meet with modern gentlemen and ladies, with *secretaries at war*, *paymasters*, *commissary generals*, and *lord high admirals*. It is true the Memoirs of the Court of Augustus is no translation; but with respect to costume, it is necessarily subject to the laws of translation.

Offences against costume are often committed by the use of improper words as well as of improper phrases. To introduce into dignified and solemn composition words associated with mean and ludicrous subjects, is equally a fault in an original author and in a translator; and it is obviously improper, in the translation of works of very high antiquity, to make use of words which have but lately been admitted into the language of the translator. Faults of this kind are very frequent in Dr Geddes's translation of the Bible, as when the *passover* is called the *skipover*; the tabernacle of the congregation, the *convention tent*; and a burnt-offering, a *holocaust*. The first of these expressions presents to the imagination an image profanely ludicrous; the second, brings into our view the French Convention, which, we suspect, occupied no small portion of the Doctor's thoughts, when they should have been wholly employed on the sacred text; and the word *holocaust*, which must be unintelligible to the mere English reader, is, in the mind of every man of letters, closely associated with the abominable rites performed at the sacrifices of the ancient heathens. But it is needless to point out faults of this kind in a work which is open to more serious objections, and which, we trust, shall never be generally read. We are sorry that truth compels us to say, that the novel expressions introduced by Dr Campbell into his version of the gospels—such as *confluence* for multitude, and *reign* for kingdom—are, to say the best of them, no improvements of the authorised version. We will not rank them with Dr Geddes's innovations, because we will not class the great author of the *Dissertation on Miracles* with a paradoxical Christian of no communion; but we do not think that Dr Campbell's laurels were freshened on his brow by the translation of the Gospels.

We shall conclude this article with the following reflections, taken from the Essay which has been so often quoted:

"If the order in which we have classed the three general laws of translation be their just and natural arrangement, which, we presume, will hardly be denied, it follows, that, in every case where it is necessary to make a sacrifice of one of these laws to another, a due regard ought to be paid to their rank and comparative importance. When the genius of the original language differs much from that of the translation, it is often necessary to depart from the author's manner in order to convey a faithful picture of his sense; but it would be highly preposterous to depart, in any case, from the sense, for the sake of imitating the manner. Equally improper would it be, to sacrifice either the sense or manner of the original, if these can be preserved consistently with purity of expression, to a fancied ease or superior gracefulness of composition; and it is certain that the sense may always be preserved, though to purity of expression the manner of the original must sometimes be sacrificed."

TRAPEZOID, sometimes denotes a trapezium that has two of its sides parallel to each other; and sometimes an irregular solid figure, having four sides not parallel to each other.

TRAVERSE, in gunnery, is the turning a piece of ordnance about, as upon a centre, to make it point in any particular direction.

TRAVERSE, in fortification, denotes a trench with a little parapet, sometimes two, one on each side, to serve as a cover from the enemy that might come in flank.

TRAVERSE, in a wet foss, is a sort of gallery, made by throwing saucissons, joists, fascines, stones, earth, &c. into the foss, opposite the place where the miner is to be put, in order to fill up the ditch, and make a passage over it.

TRAVERSE also denotes a wall of earth, or stone, raised across a work, to stop the shot from rolling along it.

TRAVERSE also sometimes signifies any retrenchment, or line fortified with fascines, barrels, or bags of earth, or gabions.

TRAVESTY, or burlesque translation, is a species of writing which, as it partakes, in a great degree, of original composition, is not to be measured by the laws of serious translation. It conveys neither a just picture of of the fentiments, nor a faithful reprefentation of the ftyle and manner of the original; but pleafes itfelf in exhibiting a ludicrous character of both. It difplays an overcharged and grotefque refemblance, and excites our rifible emotions by the incongruous affociation of dignity and meannefs, wifdom and abfurdity. This affociation forms equally the bafis of travefty and of ludicrous parody, from which it is no otherwife diftinguifhed than by its affuming a different language from the original. In order that the mimickry may be underftood, it is neceffary that the writer choofe, for the exercife of his talents, a work that is well known, and of great reputation. Whether that reputation is deferved or unjuft, the work may be equally the fubject of burlefque imitation. If it has been the fubject of general but undeferved praife, a parody or a travefty is then a fair fatire on the falfe tafte of the original author and his admirers, and we are pleafed to fee both become the objects of a juft caftigation. The *Rehearfal*, *Tom Thumb*, and *Crononhotonthologos*, which exhibit ludicrous parodies of paffages from the favourite dramatic writers of the times, convey a great deal of juft and ufeful criticifm. If the original is a work of real excellence, the travefty or parody detracts nothing from its merit, nor robs the author of the fmalleft portion of his juft praife. We laugh at the affociation of dignity and meannefs; but the former remains the exclufive property of the original, the latter belongs folely to the copy. We give due praife to the mimical powers of the imitator, and are delighted to fee how ingenioufly he can elicit fubjects of mirth and ridicule from what is grave, dignified, pathetic, or fublime.

But this fpecies of compofition pleafes only in a fhort fpecimen. We cannot bear a lengthened work in travefty. The incongruous affociation of dignity and meannefs excites rifibility chiefly from its being unexpected. Cotton's and Scarron's Virgil entertain but for a few pages: the compofition foon becomes tedious, and at length difgufting. We laugh at a fhort exhibition of buffoonery; but we cannot endure a man who, with good talents, is conftantly playing the fool.

TREACLE (fee *Encycl.*) or MELASSES, is a fubftance very wholefome, but of a tafte difagreeably fweet. Methods have accordingly been propofed for purifying it, fo as that it may, on many occafions, fupply the place of refined fugar, which has long been at a price which a great number of poor perfons cannot afford to pay for what muft now be confidered as a neceffary of life. The following is the procefs for purifying treacle, given by the M. Cadet (Devaux) in the *Feuille du Cultivateur*, founded upon experiments made by Mr Lowitz of Peterfburgh:

Take of treacle 24 lbs. of water 24 lbs. of charcoal, thoroughly burnt, 6 lbs. Bruife the charcoal grofsly, mix the three fubftances in a caldron, and let the mixture boil gently upon a clear wood fire. After it has boiled for half an hour, pour the liquor through a ftraining-bag, and then replace it upon the fire, that the fuperfluous water may be evaporated, and that the treacle may be brought to its original confiftence. There is little or no lofs by this operation, as 24 lbs. of treacle give nearly the fame quantity of fyrup.

This procefs has been repeated in the large way, and has fucceeded: the treacle is fenfibly ameliorated, fo that it may be ufed for many difhes; neverthelefs, thofe with milk, and the fine or aromatic *liqueurs*, are not near fo good as with fugar.

TREBISOND, a large, populous, and ftrong town of Turkey in Afia, in the province of Jenich, with a Greek archbifhop's fee, a harbour and a caftle. It is feated at the foot of a very fteep hill. The walls are fquare and high, with battlements; and are built with the ruins of ancient ftructures, on which are infcriptions not legible. The town is not populous; for there are more woods and gardens in it than houfes, and thefe but one ftory high. The caftle is feated on a flat rock, with ditches cut therein. The harbour is at the eaft end of the town, and the mole built by the Genoefe is almoft deftroyed. It ftands on the Black Sea, 104 miles north-weft of Erzerum, and 440 eaft of Conftantinople. E. Lon. 40° 25′. N. lat. 40° 45′.

TREE. Under this title (*Encycl.*) we gave an account of the method recommended by Meffrs Forfyth and Hitt for curing injuries and defects in trees. The actual cautery is employed in Cevennes, and in the department de l'Allier, in France, for ftopping the progrefs of rottennefs in large trees. When they perceive that this very common and deftructive difeafe begins to make fome progrefs in the chefnut-tree, by excavating its trunk, they collect heath and other combuftible vegetables, and burn them in the very cavity, till the furface is completely converted into a coal. It feldom happens that the tree perifhes by the effect of this operation, and it is always found that this remedy fufpends the progrefs of the decay. It is practifed in the fame manner, and with fimilar fuccefs, on the white oak. When we compare the effects of the actual cautery on the animal fyftem, in fimilar difeafes, a new refemblance is feen between the difeafes which affect the organic beings of both kingdoms, as well as between the remedies by which they may be oppofed.—*Nicholfon's Journal.*

TRIANGLE, ARITHMETICAL, a kind of numeral triangle, or triangle of numbers, being a table of certain numbers difpofed in form of a triangle. It was fo called by Pafcal; but he was not the inventor of this table, as fome writers have imagined, its properties having been treated of by other authors fome centuries before him, as is fhewn in Dr Hutton's Mathematical Tracts, vol. i. p. 69. &c.

The form of the triangle is as follows:

1					
1	1				
1	2	1			
1	3	3	1		
1	4	6	4	1	
1	5	10	10	5	1
1	6	15	20	&c.	
1	7	21	&c.		
1	8	&c.			
1	9				

And it is conftructed by adding always the laft two numbers of the next two preceding columns together, to give the next fucceeding column of numbers.

The firft vertical column confifts of units; the fecond, a feries of the natural numbers 1, 2, 3, 4, 5, &c.; the third, a feries of triangular numbers 1, 3, 6, 10, &c.; the fourth, a feries of pyramidal numbers, &c. The oblique diagonal rows, defcending from left to right, are alfo the fame as the vertical columns. And the numbers taken on the horizontal lines are the co-efficients of the different powers of a binomial. Many other properties and ufes of thefe numbers have been delivered by various authors, as may be feen in the Introduction to Hutton's Mathematical Tables, pages 7, 8, 75, 76, 77, 89, second edition.

TRIANGULAR COMPASSES, are such as have three legs or feet, by which any triangle, or three points, may be taken off at once. These are very useful in the construction of maps, globes, &c.

TRIANGULAR Numbers, are a kind of polygonal numbers; being the sums of arithmetical progressions, which have 1 for the common difference of their terms.

Thus, from these arithmeticals 1 2 3 4 5 6, are formed the triangular numbers 1 3 6 10 15 21, or the third column of the arithmetical triangle above-mentioned.

The sum of any number n of the terms of the triangular numbers, 1, 3, 6, 10, &c. is =

$$\frac{n^3}{6}+\frac{n^2}{2}+\frac{n}{3}, \text{ or } \frac{n}{1}\times\frac{n+1}{2}\times\frac{n+2}{3}$$

which is also equal to the number of shot in a triangular pile of balls, the number of rows, or the number in each side of the base, being n.

The sum of the reciprocals of the triangular series, infinitely continued, is equal to 2; viz.

$$1+\tfrac{1}{3}+\tfrac{1}{6}+\tfrac{1}{10}+\tfrac{1}{15}, \&c. = 2.$$

For the rationale and management of these numbers, see *Malcolm*'s *Arith.* book 5. ch. 2.; and *Simpson*'s *Algeb.* sec. 15.

TRIESTE, a small, but strong and ancient seaport of Italy, in Istria, on the gulph of Venice, with a bishop's see. It is beautifully situated on the side of a hill, about which the vineyards form a semicircle. The streets are narrow; but there is a large square, where they keep the annual fair. The harbour is spacious, but not good; because it is open to the W. and S. W. winds. The inhabitants have a good trade in salt, oil, almonds, iron, &c. brought from Laubach; and they make good wines. The cathedral, and the late Jesuits church, are the two best buildings. It belongs to the House of Austria, and is eight miles north of Capo d'Istria, and 80 north-east of Venice. E. Long. 14. 4. N. Lat. 45. 56.

TRINITARIANS (Order of), was instituted at Rome in the year 1198, under the pontificate of Innocent III. the founders whereof were John de Matha and Felix de Valois. His Holiness gave them permission to establish this order for the deliverance of captives, who groaned under the tyranny of the infidels: he gave them as a habit a white gown, ornamented with a red and blue cross. After the death of the two founders, Pope Honorious III. continued the order; and their rule was approved by his successor Clement IV. in 1367. At first they were not permitted to eat flesh; and when they travelled, were to ride only upon asses. But their rule was corrected and mitigated by the bishop of Paris, and the abbots of St Victor and St Genevieve, who allowed them to eat any kind of food, and to use horses. This order possessed, at one time, about 250 convents in 13 different provinces: six of which were in France; namely, France, Normandy, Picardy, Champaine, Languedoc, and Provence; three in Spain, viz. New Castile, Old Castile, and Arragon; one in Italy, and one in Portugal. There was formerly the province of England, where this order had 43 houses; that of Scotland, where it had nine; and that of Ireland, where it had 52; besides a great number of monasteries in Saxony, Hungary, Bohemia, and other countries. The convent of Cerfroy in France was head of the order. It is impossible for us to say what is now the state of the order, which can have no visible existence in France, and is probably suppressed even in Italy.

TRIONES, in astronomy, a sort of constellation, or assemblage of seven stars in the Ursa Major, popularly called *Charles's Wain.*—From the *septem triones* the north pole takes the denomination *septentrio.*

TRIPOLI OF SYRIA is, according to Mr Browne, by no means so populous a place as we were led to represent it in the *Encyclopædia.* It is indeed, he says, a city of some extent, situated about a mile and a half from the sea; but instead of sixty, he estimates its population at about sixteen thousand. The air is rendered unwholesome by much stagnant water. The town is placed on a slight elevation, the length considerably exceeding the breadth. On the highest ground, to the south, is the castle, formerly possessed by the earls of Tripoli; it is large and strong. Hence is visible a part of mount Libanus, the summit of which is covered with snow. The gardens in the vicinity are rich in mulberry and other fruit trees. The city is well built, and most of the streets are paved.

Here is found a number of Mahommedan merchants, some of the richest and most respectable in the empire. Silk is the chief article of commerce.

The *miri*, or fixed public revenue paid by Tripoli to Constantinople, is only about L.1000 Sterling, 20 purses, a-year. Syria at present contains only four Pashaliks, Damascus, Aleppo, Acré, and Tripoli; the last of which is the smallest in territory and power. Our author observed no antiquities at Tripoli; but the country round it is noted for producing the best tobacco in Syria.

TRISECTION, the dividing a thing into three equal parts. The term is chiefly used in geometry, for the division of an angle into three equal parts. The *trisection of an angle* geometrically, is one of those great problems, whose solution has been so much sought for by mathematicians for 2000 years past; being, in this respect, on a footing with the famous quadrature of the circle, and the duplicature of the tube.

TRISTAN D'ACHUNA, the largest of three islands which were visited by Lord Macartney and his suite on the 31st of December 1792. The other two are distinguished by the names of *Inaccessible* and *Nightingale* islands. "Inaccessible (as Sir Erasmus Gower observed) seems to deserve that name, being a high, bluff, as well as apparently barren plain, about nine miles in circumference, and has a very forbidding appearance. There is a high rock detached from it at the south end. Its latitude is 37° 19′ south; its longitude 11° 50′ west from Greenwich. This rude-looking spot may be seen at 12 or 14 leagues distance. Nightingale island is irregular in its form, with a hollow in the middle, and is about seven or eight miles in circumference, with small rocky isles at its southern extremity. It is described as having anchorage on the north-east side. Its latitude is 37° 29′ south; and longitude 11° 48′ west from Greenwich. It may be seen at seven or eight leagues distance. The largest of these three islands, which comparatively may be called the great isle of *Tristan d'Acunha*, is very high, and may be seen at 25 leagues distance. It seems not to exceed in circumference 15 miles. A part of the island towards the north rises perpen-

perpendicularly from the fea to a height apparently of a thoufand feet or more. A level then commences, forming what among feamen is termed *table land*, and extending towards the centre of the ifland; from whence a conical mountain rifes, not unlike in appearance to the Peak of Teneriffe, as feen from the bay of Santa Cruz. Boats were fent to found and to examine the fhore for a convenient place to land and water. In confequence of their report, the Lion (a fhip of 64 guns) ftood in, and came to anchor in the evening on the north fide, in 30 fathoms water, one mile from the fhore; the bottom black fand with flime; a fmall rock, off the weft point, bearing fouth-weft by fouth, juft open with the weftern extremity of the ifland; a cafcade, or fall of water, emptying itfelf upon the beach, fouth by eaft. All the fhore, from the fouthern point to the eaftern extremity, appears to be clear of danger, and fteep, except the weft point, where there are breakers about two cables length, or near 500 yards from the fhore. The fhip, when anchored, was overfhadowed by the dark mafs of that portion of the ifland whofe fides feemed to rife, like a mofs-grown wall, immediately from the ocean. On the right the elevation was lefs rapid, and between the rifing part and the fea was left a flat, of fome extent, covered with fedge grafs, interfperfed with fmall fhrubs, which, being perfectly green, looked from the fhip like a pleafant meadow, watered by a ftream that fell, afterwards, from its banks upon the beach. The officers, who went afhore, reported, that the cafks might be filled with frefh water by means of a long hofe, without moving them from the boats. The landing place thereabouts was alfo defcribed as being fafe, and fuperior to any other that had been examined. From the plain, the land rofe gradually towards the central mountain, in ridges covered with trees of a moderate fize and height. The coaft abounded with fea lions and feals, penguins and albatroffes. One of the latter was brought on board, his wings meafuring ten feet from tip to tip; but others are faid to have been found much larger. The coaft was covered with a broad fea weed, feveral fathoms long, and defervedly by naturalifts termed *gigantic fucus*. Some good fifh was caught with the hook and line.

"The accident of a fudden guft, by which the anchor was in a few hours driven from its hold, and the fhip forced out to fea, prevented the ifland from being explored, as was intended. It is probable that had the Lion anchored in 20, inftead of 30 fathoms water, the anchor would have held firmly. Some advantage was obtained, however, from coming to this place. The juft pofition of thofe iflands, in refpect to their longitude, was afcertained, by the mean of feveral time-pieces, to be about two degrees to the eaftward of the place where they are laid down in charts, taken from obfervations made at a period when the inftruments for this purpofe were lefs accurate than at prefent. The fpot where the Lion anchored was determined, by good meridional obfervations, and by accurate time-pieces, to be 37° 6′ fouth latitude, and 11° 43′ weft longitude from Greenwich. The compafs had feven degrees of variation weftward from the pole. Fahrenheit's thermometer ftood at 67 degrees. It was ufeful alfo to have afcertained, that a fafe anchorage, and plenty of good water, were to be found here. Thefe iflands are certainly worthy of a more particular inquiry; for they are not 50 leagues from the general track of veffels bound to China, and to the coaft of Coromandel, by the outer paffage. In war time, an excellent rendezvous might be fettled there, for fhips that wanted no other fupply but that of water. When circumftances require particular difpatch, it is practicable to come from England to Triftan d'Acunha without ftopping in the way, and afterwards to the end of the voyage to India or China."

Thefe iflands are feparated by a fpace of about fifteen hundred miles from any land to the weftward or northward of them. They are fituated in that part of the fouthern hemifphere, in the neighbourhood of which a continent, to balance the quantity of land in the northern hemifphere, was once expected to be found, but where it has been fince difcovered that there is none. Of what extent, however, the bafes of thefe iflands are under the furface of the fea, cannot be afcertained; or whether they may, or may not, be fufficient to make up for the defect of land appearing above water. Navigators report, that to the eaftward of them are other fmall iflands, differing not much in latitude, fuch as Gough and Alvarez iflands, and the Marfouines; as well as extenfive fhoals, lying due fouth of the moft foutherly point of Africa, and extending eafterly feveral degrees. That all thefe together form a chain, fome of fubaqueous, and fome of fuperaqueous mountains, but all connected by their roots, is perhaps a conjecture lefs improbable, than that they fhould feparately arife, like tall columns, from the vaft abyfs.

A fettlement in Triftan d'Acunha is known to have been twice in the contemplation of adventurers, but not as yet to have been carried into execution. One had the project of rendering it a mart for the change of the light manufactures of Hindoftan, fuited to hot climes, for the filver of the Spanifh fettlements in South America; in the route between which places it is conveniently fituated. The other plan meant is only as a fuitable fpot for drying and preparing the furs of fea lions and feals, and for extracting the fpermaceti of the white or long-nofed whale, and the whale-bone and oil of the black fpecies. Whales of every kind were feen fporting about Triftan d'Acunha, particularly near the fetting of the fun; and the fword-fifh likewife made its appearance occafionally.—*Sir George Staunton's Account of the Embaffy to China.*

TRITON, in zoology, a genus belonging to the order of vermes mollufca. The body is oblong; the tongue is fpiral; it has twelve tentacula, fix on each fide, the hindmoft ones having claws like a crab. There is but one fpecies, found in holes of rocks about the fhore.

TROTTER (Mrs Catharine), was the daughter of Captain David Trotter, a Scotch gentleman. He was a commander in the royal navy in the reign of Charles II. and at his death left two daughters, the youngeft of whom, Catharine, our celebrated author, was born in London, Auguft 1679. She gave early marks of her genius; and learned to write, and alfo made herfelf miftrefs of the French language, by her own application and diligence, without any inftructor; but fhe had fome affiftance in the ftudy of the Latin grammar and logic; of which latter fhe drew up an abftract for her own ufe. The moft ferious and important fubjects, and efpecially religion, foon engaged her attention.—But notwithftanding her education, her intimacy with feveral families of diftinction of the Romifh perfuafion, expofed her, while very young, to impreffions in favour of

Trotter. of that church; which not being removed by her conferences with some eminent and learned members of the church of England, she embraced the Romish communion, in which she continued till the year 1707. In 1695, she produced a tragedy called *Agnes de Castro*, which was acted at the theatre-royal when she was only in her 17th year. The reputation of this performance, and the verses which she addressed to Mr Congreve upon his Mourning Bride, in 1697, were probably the foundation of her acquaintance with that celebrated writer. Her second tragedy, *Fatal Friendship*, was acted in 1698, at the new theatre in Lincoln's-Inn-Fields. This tragedy met with great applause, and is still thought the most perfect of her dramatic performances. Her dramatic talents not being confined to tragedy, she brought upon the stage, in 1701, a comedy called *Love at a loss*, or *Most votes carry it*. In the same year she gave the public her third tragedy, entitled the *Unhappy Penitent*, acted at the theatre-royal in Drury-lane. But poetry and dramatic writing did not so far engross the thoughts of our author but that she sometimes turned them to subjects of a very different nature; and distinguished herself in an extraordinary manner in defence of Mr Locke's writings; a female metaphysician being a remarkable phenomenon in the republic of letters.

She turned to the exercise of her dramatic genius in 1703, and fixed upon the revolution of Sweden, under Gustavus Erickson, for the subject of a tragedy. This tragedy was acted, in 1706, at the Queen's theatre in the Hay-Market. In 1707, her doubts concerning the Romish religion, which she had so many years professed, having led her to a thorough examination of the grounds of it, by consulting the best books on both sides of the question, and advising with men of the best judgment, the result was a conviction of the falseness of the pretensions of that church, and a return to that of England, to which she adhered during the remainder of her life. In 1708, she was married to the Rev. Mr Cockburn, then curate of St Dunstan's in Fleet-street, but he afterwards obtained the living of Long-Horsely, near Morpeth in Northumberland. He was a man of considerable abilities; and, among several other things, wrote an account of the Mosaic Deluge, which was much approved by the learned.

Mrs Cockburn's remarks upon some writers in the controversy concerning the foundation of moral duty and moral obligation, were introduced to the world, in August 1743, in the Literary Journal, intitled *The History of the Works of the Learned.* The strength, clearness, and vivacity shewn in her remarks upon the most abstract and perplexed questions, immediately raised the curiosity of all good judges about the concealed writer; and their admiration was greatly increased when her sex and advanced age were known. Dr Rutherforth's Essay on the Nature and Obligations of Virtue, published in May 1744, soon engaged her thoughts; and notwithstanding the asthmatic disorder which had seized her many years before, and now left her small intervals of ease, she applied herself to the confutation of that elaborate discourse, and finished it with a spirit, elegance, and perspicuity equal, if not superior, to all her former writings.

The loss of her husband in 1748, in the 71st year of his age, was a severe shock to her; and she did not long survive him, dying on the 11th of May 1749, in her 71st year, after having long supported a painful disorder with a resignation to the Divine will, which had been the governing principle of her whole life, and her support under the various trials of it.

Her works are collected into two large volumes 8vo, by Dr Birch; who has prefixed to them an account of her life and writings.

Trumpet Marine. TRUMPET Marine, or Marigny. This is a stringed instrument, invented in the 16th century by an Italian artist Marino or Marigni, and called a *trumpet*, because it takes only the notes of the trumpet, with all its omissions and imperfections, and can therefore execute only such melodies as are fitted for that instrument. It is a very curious instrument, though of small musical powers, because its mode of performance is totally unlike that of other stringed instruments; and it deserves our very particular attention, because it lays open the mechanism of musical sounds more than anything we are acquainted with; and we shall therefore make use of it in order to communicate to our readers a philosophical theory of music, which we have already treated in detail as a liberal or scientific art.

The trumpet marine is commonly made in the form of a long triangular pyramid, ABCD, fig. A. on which a single string EFG is strained over a bridge F by means of the finger pin L. At the narrow end are several frets 1, 2, 3, 4, 5, &c. between E and K, which divide the length EF into aliquot parts. Thus E 1 is $\frac{1}{11}$ of EF, E 2 is $\frac{1}{11}$, and so on. The bow is drawn lightly across the cord at H, and the string is stopped by pressing it with the finger immediately above the frets, but not so hard as to make it touch the fret. When the open string is sounded, it gives the fundamental note. If it be stopped, in the way now described, at $\frac{1}{3}$d of its length from E, it yields the 12th of the fundamental; if stopped at $\frac{1}{4}$th, it gives the double octave; if at $\frac{1}{5}$th, it gives the 17th major, &c. In short, it always gives the note corresponding to the length of the part between the fret and the note E. The sounds resemble those of a pipe, and are indeed the same with those known by the name *harmonics*, and now executed by every performer on instruments of the viol or violin species. But in order to increase the noise, the bridge F is constructed in a very particular manner. It does not rest on the sound-board of the instrument through its whole breadth, but only at the corner *a*, where it is firmly fixed. The other extremity is detached about $\frac{1}{100}$th of an inch from the sound board; and thus the bridge, being made to tremble by the strong vibration of the thick cord, rattles on the sound-board, or on a bit of ivory glued to it. The usual way in which this motion is procured, is to have another string passing under the middle of the bridge in such a manner that, by straining it tight, we raise the corner *b* from the sound board to the proper height. This contrivance increases prodigiously the noise of the instrument, and gives it somewhat of the smart sound of the trumpet, tho' very harsh and coarse. But it merits the attention of every person who wishes to know any thing of the philosophy of musical sounds, and we shall therefore say as much on the subject as will conduce to this effect. Plate XLV.

Galileo, as we have observed in the article Temperament, *Suppl.* was the first who discovered the real connection between mathematics and music, by demonstrating that the times of the vibrations of elastic cords of of the fame matter and fize, and ftretched by equal weights, are proportional to the lengths of the ftrings. He inferred from this that the mufical pitch of the found produced by a ftretched cord depended folely on the frequency of the vibrations. Moreover, not being able to difcover any other circumftance in which thofe founds phyfically refembled each other, and reflecting that all founds are immediately produced by agitations of air acting on the ear, he concluded that each vibration of the cord produced a fonorous pulfe in the air, and therefore that the pitch of *any* found whatever depended on the frequency of the aerial pulfes. In this way alone the found of a ftring, of a bell, of an organ pipe, and the bellow of a bull, may have the fame pitch. He could not, however, demonftrate this in any cafe but the one above mentioned. But he was encouraged to hope that mathematicians would be able to demonftrate it in all cafes, by his having obferved that the fame proportions obtained in organ pipes as in ftrings ftretched by equal weights. But it required a great progrefs in mechanical philofophy, from the ftate in which Galileo found it, before men could fpeculate and reafon concerning the pulfes of air, and difcover any analogy between them and the vibrations of a ftring. This analogy, however, was difcovered, and its demonftration completed, as we fhall fee by and by. In the mean time, Galileo's demonftration of the vibrations of elaftic cords became the foundation of all mufical philofophy. It muft be thoroughly underftood before we can explain the performance of the trumpet marine.

The demonftration of Galileo is remarkable for that beautiful fimplicity and perfpicuity which diftinguifh all the writings of that great mechanician, and it is the elementary propofition in all mechanical treatifes of mufic. Few of them indeed contain any thing more; but it is extremely imperfect, and is juft only on the fuppofition that all the matter of the ftring is collected at its middle point, and that the reft of it has elafticity without *inertia*. This did not fuit the accurate knowledge of the 17th century, after Huyghens and Newton had given the world a tafte of what might be done by profecuting the Galilean mechanics. When a mufical cord has its middle point drawn afide, and it is strained into the fhape of two ftrait lines, if it be let go, it will be obferved not to vibrate in this form. It may eafily be feen in the extremity of its excurfions, where it refts, before it return by its elafticity. The reafon is this (fee fig. B.) When the middle point C of the cord is drawn afide, and the cord has the form of two ftraight lines AC, CB, this point C, being pulled in the directions CA, CB, at once, is really accelerated in the direction CD, which bifects the angle ACB; and if it were then detached from the reft of the material cord, it would move in that direction. But any other point *f* between C and B has no accelerating force whatever acting on it. It is equally pulled in the directions *f* C and *f* B. The particle C therefore is obliged to drag along with it the inert matter of the reft of the cord; and when it has come to any intermediate fituation *c*, the cord cannot have the form of two ftraight lines A *c*, *c* B, with the particle *f* fituated in *f*. This particle will be left fomewhat behind, as in φ, and the cord will have a curved form A *c* φ B; and in this form it will vibrate, going to the other fide, and affuming, not the rectilineal form ADB, but the curved form A δ B. That every particle of the curve A *e c* φ *f* B is now accelerated toward the axis AB is evident, becaufe every part is curved, and the whole is ftrained toward A and B, which tends to ftraiten every part of it. But in order that the whole may arrive at the axis in one moment, and conftitute a ftraight line AB, it is evidently neceffary that the accelerating force on every particle be as the diftance of the particle from that point of the axis at which it arrives. It is well known to the mathematician that the accelerating force by which any particle is urged towards a rectilineal pofition, with refpect to the adjoining particles, is proportional to the curvature. Our readers, who are not familiar with fuch difcuffions, may fee the truth of this fundamental propofition by confidering the whole of A *c* B as only a particle or minute portion of a curve, magnified by a microfcope. The force which ftrains the curve may be reprefented by *c* A or AE. Now it is well known (and is the foundation of Galileo's demonftration) that the ftraining force is to the force with which *c* is accelerated in the direction *c* E as A *c* to *c* D, or as AE to *c* D, or as AE to twice *c* E. Now *c* E is the meafure of the curvature of A *c* B, being its deflection from a right line. Therefore when the ftraining force is the fame all over the curve, the accelerating force, by which any portion of it tends to become ftraight, is proportional to the curvature of that portion. And if *r* be the radius of a circle paffing through A, *c*, and B, and coinciding with this element of a curve, it is plain that $c\,D : c\,A = c\,A : r$, or that the radius of curvature is to the element *c* A as the extending force to the accelerating force; and $c\,D = \frac{c\,A^2}{r}$; and is inverfely as *r*, or directly as the curvature.

Hence we fee the nature of that curve which a mufical cord muft have, in order that all its parts may arrive at the axis at once. The curvature at *c* muft be to the curvature at *f* as E *c* to *g f*. But this may not be enough. It is farther neceffary that when *c* has got half way to E, the curvature in the different points of the new curve into which the cord has now arranged itfelf, be alfo, in every point, proportional to the diftance from the axis. Now this *will* be the cafe if the extreme curve has been fuch. For, taking the cord in any other fucceffive fhape, the diftance which each point has gone in the fame moment muft be proportional to the force which impelled it; therefore the remaining diftances of all the points from the axis will have the fame proportions as before. And the geometrical and evident confequence of this is, that the curvatures will alfo be in the fame proportion.

Therefore a cord that is once arranged in this form will always preferve it, and will vibrate like a cycloidal pendulum, performing its ofcillations in equal times, whether they be wide or narrow. Therefore fince this perfect ifochronifm of vibrations is all that is wanted for preferving the fame mufical pitch or tone, this cord will always have the fame note.

This propofition was the difcovery of Dr Brooke Taylor, one of the ornaments of our country *, and is publifhed in his celebrated work *Methodus Incrementorum*. The inveftigation, however, and the demonftration in that work, are fo obfcure and fo tedious that few had patience to perufe them. It was more elegantly treated afterwards by the Bernoullis and others. The curve

* See his life, *Encyc.*

curve got the name of the *Taylorean curve;* and is considered by many eminent mathematicians as a trochoid, *viz.* the curve defcribed by a point in the nave or fpoke of a wheel while the wheel rolls along a ftraight line. But this is a miftake, although it is allied to the trochoid in the fame manner that the figure of fines is allied to the cycloid. Its phyfical property intitles it to the name of the HARMONICAL CURVE. As this curve is not only the foundation of all our knowledge of the vibration of elaftic cords, but alfo furnifhes an equation which will lead the mathematician through the whole labyrinth of aereal undulations, and be of ufe on many other occafions; and as the firft mathematicians have, through inattention, or through enmity to Dr Taylor, affected to confider it as the trochoid already well known to themfelves—we fhall give a fhort account of its conftruction and chief properties, fimplified from the elegant defcription given by Dr Smith in his Harmonics.

Let SDTV, QERP (fig. C.), be circles defcribed round the centre C. Draw the diameters QCR, ECP, cutting each other at right angles. From any point G in the exterior circle draw the radius GC, cutting the interior circle in F, draw KHFI parallel to QCR, and make HI, HK, each equal to the arch EG. Let this be done for every point of the quadrantal arch EGR. The points I, K, are in the harmonic curve; that is, the curve AKDIB paffing through the points K and I, determined by this conftruction, has its curvature in every point K proportional to the diftance KN from the bafe AB.

To demonftrate this, draw FL perpendicular to the axis, and join EL. Take another point g in the outer circle indefinitely near to G. Draw $g\,c$, cutting the inner circle in f, and $f\,h$ and $f\,l$ perpendicular to DC, CT, and join E l. Then fuppofe two lines K m' K m' perpendicular to the curve in K and k. They muft meet in m', the centre of the equicurve circle. Draw KN n' perpendicular to the bafe, and $m'\,n'$ parallel to it, and join $k\,n$. Laftly, draw XL x perpendicular to EL.

It is plain that k O, the difference of HK and $h\,k$, is equal to Gg, the difference of GE and g E, and that KO is equal to F r, and L l to $r\,f$. Alfo, becaufe ELX is a right angle, $\text{EX} = \frac{\text{EL}^2}{\text{EC}}$.

We have $\text{F}r : \text{F}f = \text{CL} : \text{CF}, = \text{CL} : \text{CD}$.

$\text{F}f : \text{G}g = \quad \text{CD} : \text{CE}$.

Therefore $\text{F}r : \text{G}g$, or $\text{KO} : \text{O}k = \text{CL} : \text{CE}$.

The triangles ECL and k OK are therefore fimilar, as are alfo k OK and K$n\,m$, and confequently ECL and K $n\,m$; and becaufe EC is parallel to K n, EL is parallel to Km. For the fame reafon km is parallel to El, and the triangles E $l\,x$ and m K k are fimilar, and

$$\text{L}x : \text{K}k = \text{LE} : \text{K}m$$

and $\text{L}x : \text{K}k = \text{EC} : \text{K}n$. But farther,

$$\text{L}x : \text{L}l = \text{CE} : \text{CL}$$

$$\text{L}l : \text{F}f = \text{KN} : \text{CD}, \text{ being } = \text{FL} : \text{FC}$$

$$\text{F}f : \text{G}g = \text{CD} : \text{CE}, \text{ being } = \text{F}f : k\text{O}$$

$$\text{G}g : \text{K}k = \text{CE} : \text{CL}, \text{ being } = \text{KO} : \text{K}k.$$

Therefore $\text{L}x : \text{K}k = \text{KN}\times\text{CE} : \text{EL}^2, = \text{KN} : \text{EX}$.

Therefore $\text{KN} : \text{EX} = \text{LE} : \text{K}m$, and $\text{K}m = \frac{\text{EX}\cdot\text{LE}}{\text{KN}}$,

and $\text{KN} : \text{EX} = \text{CE} : \text{K}n$, and $\text{K}n = \frac{\text{EX}\cdot\text{CE}}{\text{KN}}$.

In the very narrow vibrations of mufical cords, CD is exceedingly fmall in comparifon with C E, fo that EX·EL, or EX·CE, may, without fenfible error, be taken for CE², and then we obtain K m or K n (which hardly differ) $= \frac{\text{CE}^2}{\text{KN}}$, and therefore the curvature is proportional to KN. The fmall deviation from this ratio would feem to fhew that this conftruction does not give the harmonic curve with accuracy. But it is not fo. For it will be found, that although the curvature is not as KN, it is ftill proportional to the fpace which any particle K muft really defcribe in order to arrive at the axis. Thefe paths are lines whofe curvatures diminifh as they approach to DC.

We fee 1*ft*, that the bafe ACB of the curve is equal to the femicircular arch QER.

2*d*, Alfo that the tangent KZ in any point K is perpendicular to EL.

3*d*, We learn that the curvature at A and B is nothing, for in thefe two points KN is nothing.

4*th*, The radius of curvature at D is precifely $= \frac{\text{CE}^2}{\text{CD}}$.

Therefore, as the ftring approaches the axis, and CD diminifhes, the curvature diminifhes in the fame proportion. The vibrations therefore are performed like thofe of a pendulum in a cycloid, and are ifochronous, whether wide or narrow, and therefore the mufical pitch is conftant.

This is not ftrictly true, becaufe in the wide vibrations the extenfion or extending force is fomewhat greater. Hence it is that a ftring when violently twanged founds a little fharper at the beginning. Dr Long made a harpfichord whofe ftrings were ftretched by weights, by which this imperfection was removed.

It is proper to exhibit the curvature at D in terms of the length AB, and of the greateft excurfion c D. Therefore let c be the circumference of a circle whofe diameter is 1. Let AB the length of the cord be $=$ L, and let CD the $\frac{1}{2}$ breadth of the vibration be B. We had a little ago $\text{D}\,m = \frac{\text{CE}^2}{\text{CD}}$, but $c : 1 = \text{AB} : \text{CE}$, and $\text{CE} = \frac{\text{AB}}{c}$, and $c\,\text{E}^2 = \frac{\text{AB}c}{c^2}$. Therefore $\text{D}m = \frac{\text{AB}^2}{c^2\times\text{CD}} = \frac{\text{L}^2}{9{,}87\text{CD}}$ nearly.

We can now tell the number of vibrations made in a fecond by a ftring. This we obtain by comparing its motion, when impelled by the accelerating force which acts on it, with its motion when acted on by its weight only. Therefore let L be the length of a ftring, and W its weight, and let E be the ftraining weight, or extending force: Let f be the force which accelerates the particle D d of the cord, and w the weight of that particle, while W is the weight of the whole cord. Let z be the fpace which the particle D d would defcribe during the time of one vibration by the uniform action of the force f, and let S be the fpace which it would defcribe in the fame time by its weight w alone. Then (DYNAMICS, *Suppl.* n° 103. cor. 6.) the time in which f would impel the particle D d along $\frac{1}{2}$ DC, is to the time of one vibration as $1 : c$. And $\frac{1}{2}$ DC is to z as the fquare of the time of defcribing $\frac{1}{2}$ DC is to the fquare of the time of defcribing z; that is, $1 : c^2 = \frac{1}{2}\text{DC} : 2\,z$, and $c^2\,\text{DC} = 2\,z$.

Now, by the property of the harmonic curve,

$$AB : Dm = 2z : AB$$
$$\text{But } Dm : Dd = E : f$$
$$\text{And } Dd : AB = w : W$$
$$\text{Therefore } 2z \cdot E \cdot w = AB \cdot f \cdot W$$
$$\text{And } f : w = 2z \times E : AB \times W$$
$$\text{But } w : f = 2S : 2z$$
$$\text{Therefore } 2S \times E = AB \times W$$
$$\text{And } 2E : W = AB : S.$$

That is, a mufical chord, extended by a force E, performs one vibration DCV in the time that a heavy body defcribes a fpace S, which is to the length of the cord as its weight is to twice the extending force.

Now let g be the fpace through which a heavy body falls in one fecond, and let the time of vibration (eftimated in parts of a fecond) be T. We have

$$AB : S = 2E : W$$
$$S : g = T^2 : 1^2$$
$$\text{Therefore } AB : g = 2E \cdot T^2 : W$$
$$\text{And } AB \times W = T^2 \times 2E \times g$$
$$\text{Therefore } T^2 = \frac{AB \times W}{2g.E}, \text{ and } T = \sqrt{\frac{AB \times W}{2g.E}}$$

Let n be the number of vibrations made in a fecond.

$$n = \frac{1}{T} = \sqrt{\frac{2g.E}{AB.W}} = \sqrt{\frac{2gE}{L.W}}.$$

If the length of the cord be meafured in feet, $2g$ is very nearly 32. If in inches, $2g$ is 386, more nearly. Therefore $n = \sqrt{\frac{32\,E}{L \cdot W}}$ or $\sqrt{\frac{386\,E}{L \cdot W}}$. This may eafily be compared with obfervation. Dr Smith hung a weight of 7 pounds, or 49,000 grains, on a brafs wire fufpended from a finger pin, and fhortened it till it was in perfect unifon with the double octave below the open ftring D of a violin. In this ftate the wire was 35,55 inches long, and it weighed 31 grains.

Now $\sqrt{\frac{384 \times 49000}{35{,}55 \times 31}} = 130{,}7 = n$. This wire, therefore, ought to make 130,7 vibrations in a fecond. Dr Smith proceeded to afcertain the number of aereal pulfes made by this found, availing himfelf of the theory of the beats of tempered confonances invented by himfelf. On his fine chamber organ he tuned upwards the perfect fifths DA, A e, e b, and then tuned downward the perfect 6th e d. Thus he obtained an octave to D, which was too fharp by a comma, and he found that it beat 65 times in 20 feconds. Therefore the number of vibrations was $\frac{65}{20}$ 81, or 263,25. Thefe were complete pulfes or motions from D to V and back again, and therefore contained $526\frac{1}{2}$ fuch vibrations as we have now been confidering. The double octave below fhould make $\frac{1}{4}$th of this, or 131,6, which is not a complete vibration more than the above theory requires: more accurate coincidence is needlefs.

This theory is therefore very completely eftablifhed, and it may be confidered as one of the fineft mechanical problems which has been folved in laft century. We mention it with greater minutenefs, becaufe the merit of Dr Taylor is not fufficiently attended to. Mr Rameau, and the other great theorifts in mufic, make no mention of him; and fuch as have occafion to fpeak of the abfolute number of vibrations made by any mufical note, always quote Mr Sauveur of the French academy. This gentleman has written fome very excellent differtations on the theory of mufic, and Sir Ifaac Newton in his *Principia* often quotes his authority. He has given the actual determination of the number of vibrations of the note C, obtained in a manner fimilar to that practifed by Dr Smith on his chamber organ, and which agrees extremely well with that meafure. But Mr Sauveur has alfo given a mechanical inveftigation of the problem, which gives the fame number of vibrations that he obferved. We prefume that Rameau and others took the demonftration for good; and thus Mr Sauveur paffes on the Continent for the difcoverer of this theorem. But it was not publifhed till 1716, though read in 1713; whereas Dr Taylor's demonftration was read to the Royal Society in May 1714. But this demonftration of Mr Sauveur is a mere paralogifm, where errors compenfate errors; and the affumption on which he proceeds is quite gratuitous, and has nothing to do with the fubject. Yet John Bernoulli, from enmity to Taylor and the Englifh mathematicians, takes not the leaft notice of this fophifticated demonftration, accommodated to the experiment, and fo devoid of any pretenfions to argument that this fevere critic could not but fee its falfity.

Sauveur was one of the firft who obferved diftinctly that remarkable fact which Mr Rameau made the foundation of his mufical theory, *viz.* that a full mufical note is accompanied by its octave, its twelfth, and its feventeenth major. It had been cafually obferved before, by Marfennus, by Perrault, and others; but Sauveur tells diftinctly how to make the obfervation, and affirms it to be true in all deep notes. Rameau afferts it to be univerfally and neceffarily true in all notes, and the foundation of all mufical pleafure.

It had been difcovered before this time, that not only a full note caufed its unifon to refound, but alfo that a 12th, being founded near any open ftring, the ftring *refounded* to this 12th. It does the fame to a 15th, a 17th major, a 22d, &c.

Dr Wallis added a very curious circumftance to this obfervation. Two of his pupils, Mr Noble and Mr Pigott, in 1673, amufing themfelves with thefe refonnances, obferved, that if a fmall bit of paper be laid on the ftring of a violin which is made to refound to its unifon, the paper is thrown off: a proof that the ftring refounded by really vibrating, and that it is thrown into thefe vibrations by the pulfes of the air produced by the other ftring. In like manner the paper is thrown off when the ftring refounds to its octave. But the young gentlemen obferved, that when the paper was laid on the middle point of the ftring, it remained without agitation, although the ftring ftill refounded. They found the fame thing when they made the ftring refound to its 12th: papers laid on the two points of divifion lay ftill, but were thrown off when laid on any other place. In fhort, they found it a general rule, that papers laid on any points of divifion correfponding to the note which was refounded, were not agitated.

Dr Wallis (the greateft theorift in mufic of the 17th century) juftly concluded that thefe points of the refounding ftring were at reft, and that the intermediate parts were vibrating, and producing the notes correfponding to their lengths.

From this Mr Sauveur, with great propriety, deduced the

Trumpet Marine.

the theory of the performance of the trumpet marine, the vielle, the clavichord, and fome other inftruments.

When the ftring of the trumpet marine is gently ftopped at $\frac{1}{2}$, and the bow drawn lightly acrofs it at H (fig. A), the full vibration at the finger is ftopped; but the ftring is thrown into vibrations of fome kind, which will either be deftroyed or may go on. It is of importance to fee what circumftance will permit their continuance.

Suppofe an elaftic cord put into the fituation ABCDE (fig. D), fuch that AB, BC, CD, DE, are all equal, and that BCD is a ftraight line. Let the point C be made faft, and the two points B and D be let go at once. It is evident that the two parts will immediately vibrate in two harmonical curves A b C and CDE, which will change to ABC and C d E, and fo on alternately. It is alfo evident that if a line FCG be drawn touching the curve ABC, it will alfo touch the curve CDE; and the line which touches the curve A b C in C, will alfo touch the curve C d E. In every inftant the two halves of the cord will be curves which have a common tangent in the point C. The undoubted confequence of this is, that the point C will not be affected by thefe vibrations, and its fixure may be taken away. The cord will continue to vibrate, and will give the found of the octave to its fundamental note.

The condition; then, which muft be implemented, in order that a ftring may refound to its octave, or take the found of its octave, is fimply this, that its two parts may vibrate equally in oppofite directions. This is evidently poffible; and when the bow is drawn acrofs the ftring of the trumpet marine at H, and irregular vibrations are produced in the whole ftring, thofe which happen to be in one direction on both fides of the middle point, where it is gently ftopped by the finger, will deftroy each other, and the confpiring ones will be inftantly produced, and then every fucceeding action of the bow will increafe them.

The fame thing muft happen if a ftring is gently ftopped at one-third of its length; for there will be the fame equilibrium of forces at the two points of divifion, fo that the fixures of thefe points may be removed, and the ftring will vibrate in three parts, founding the 12th of the fundamental.

We may obferve, by the way, that if the bow be drawn acrofs the ftring at one of the points of divifion, correfponding to the ftopping at the other end of the ftring, it will hardly give any diftinct note. It rattles, and is intolerably harfh. The reafon is plain: The bow takes fome hold of the point C, and drags it along with it. The cord on each fide of C is left behind, and therefore the two curves cannot have a common tangent at C. The vibrations into which it is thus jogged by the bow deftroy each other.

We now fee why the trumpet marine will not found every note. It will found none but fuch as correfpond to a divifion of the ftring into a number of equal parts, and its note will be in unifon with a ftring equal to one of thofe parts. Therefore it will *firft* of all found the fundamental, by its whole length;

2. Its octave, correfponding to - $\frac{1}{2}$ its length
3. The 12th, - - - $\frac{1}{3}$
4. The 15th, or double octave, - $\frac{1}{4}$
5. The 17th, - - - $\frac{1}{5}$
6. The 19th, - - - $\frac{1}{6}$

Mufical Trumpet.

7. The 21ft, which is not in the diatonic fcale of our mufic. - $\frac{1}{7}$ its length
8. The triple octave, or 22d, - $\frac{1}{8}$
9. The 23d, or 2d in the fcale of the triple octave, - - $\frac{1}{9}$
10. The 24th, or 3d in this fcale, $\frac{1}{10}$
11. The 25th, a falfe 4th of this fcale, $\frac{1}{11}$
12. The 26th, a perfect 5th of this fcale, $\frac{1}{12}$
13. The 27th, a falfe 6th of ditto, $\frac{1}{13}=\frac{3}{39}$ or $\frac{2}{26}$
14. The 28th, a falfe 7th minor, $\frac{1}{14}$
15. The 28th, a perfect 7th major, $\frac{1}{15}$
16. The quadruple octave, - $\frac{1}{16}$

Thus we fee that this inftrument will not execute all mufic, and indeed will not complete any octave, becaufe it will neither give a perfect 4th nor 6th. We fhall prefently fee that thefe are the very defects of the trumpet.

This fingular ftringed inftrument has been defcribed in this detail, chiefly with the view of preparing us for underftanding the real trumpet. The Vielle, Savoyarde, or Hurdygurdy, performs in the fame manner. While the wheel rubs one part of the ftring like a bow, the keys gently prefs the ftrings, in points of aliquot divifion, and produce the harmonic notes.

It is to prevent fuch notes that the part of harpfichord wires, lying between the bridge and the pins, are wrapped round with lift. Thefe notes would frequently difturb the mufic.

Laftly on this head, the Æolian harp derives its vaft variety of fine founds from this mode of vibration. Seldom do the cords perform their fundamental or fimple vibrations, They are generally founding fome of the harmonies of their fundamentals, and give us all this variety from ftrings tuned in unifon.

Trumpet, Mufical, is a wind inftrument which founds by preffing the clofed lips to the fmall end, and forcing the wind through a very narrow aperture between the lips. This is one of the moft ancient of mufical inftruments, and has appeared in all nations in a vaft variety of forms. The conch of the favage, the horn of the cow-herd and of the poftman, the bugle horn, the lituus and tuba of the Romans, the military trumpet, and the trombone, the *cor de chaffe* or French horn—are all inftruments winded in the fame manner, producing their variety of tones by varying the manner and force of blowing. The ferpent is another inftrument of the fame kind, but producing part of its notes by means of holes in the fides.

Although the trumpet is the fimpleft of all mufical inftruments, being nothing but a long tube, narrow at one end and wide at the other, it is the moft difficult to be explained. To underftand how fonorous and regulated undualtions can be excited in a tube without any previous vibration of reeds to form the waves at the entry, or of holes to vary the notes, requires a very nice attention to the mechanifm of aereal undulations, and we are by no means certain that we have as yet hit on the true explanation. We are certain, however, that thefe aereal undulations do not differ from thofe produced by the vibration of ftrings; for they make ftrings refound in the fame manner as vibrating cords do. Galileo, however, did not know this argument for his affertion that the mufical pitch of a pipe, like that of a cord, depended on the frequency alone of the aereal undulations; but he thought it highly

 probable,

probable, from his obfervations on the ftructure of organs, that the notes of pipes were related to their lengths in the fame manner as thofe of wires, and he exprefsly makes this remark. Newton, having difcovered that found moved at the rate of about 960 feet per fecond, obferved that, according to the experiments of Mr Sauveur, the length of an open pipe is half the length of an aereal pulfe. This he could eafily afcertain by dividing the fpace defcribed by found in a fecond by the number of pulfes.

Daniel Bernoulli, the celebrated promoter of the Newtonian mechanics, difcovered, or at leaft was the firft who attentively marked, fome other circumftances of refemblance between the undulations of the air in pipes and the vibrations of wires. As a wire can be made, not only to vibrate in its full length, founding its fundamental note, but can alfo be made to fubdivide itfelf, and vibrate like a portion of the whole, with points of reft between the vibrating portions, when it gives one of its harmonic notes; fo a pipe cannot only have fuch undulations of air going on within it as are competent to the production of its fundamental note, but alfo thofe which produce one of its harmonic notes. Every one knows that when we force a flute, by blowing too ftrongly, it quits its proper note, and gives the octave above. Forcing ftill more, produces the 12th. Then we can produce the double octave or 15th, and the 17th major, &c. In fhort, by attending to feveral circumftances in the manner of blowing, all the notes may be produced from one very long pipe that we produce from the trumpet marine, and in precifely the fame order, and with the fame omiffions and imperfections. This alone is almoft equivalent to a proof that the mechanifm of the undulations of air in a pipe are analogous to that of the vibrations of an elaftic cord. Having with fo great fuccefs inveftigated the mechanifm of the partial vibrations of wires, and alfo another kind of vibrations which we fhall mention afterwards, incomparably more curious and more important in the philofophy of mufical founds, Mr Bernoulli undertook the inveftigation of thofe more myfterious motions of air which are produced in pipes; and in a very ingenious differtation, publifhed in the Memoirs of the Academy of Paris for 1762, &c. he gives a theory of them, which tallies in a wonderful manner with the chief phenomena which we obferve in the wind inftruments of the flute and trumpet kind. We are not, however, fo well fatisfied with the truth of his *affumptions* refpecting the ftate of the air, and the precife form of the undulations which he affigns to it; but we fee that, notwithftanding a probability of his being miftaken in thefe circumftances (it is with great deference that we prefume to fuppofe him miftaken), the chief propofitions are ftill true; and that the changes from note to note muft be produced in the order, tho' perhaps not in the precife manner, affigned by him.

It is by no means eafy to conceive, with clearnefs, the way in which mufical undulations are excited in the various kinds of trumpets. Many who have reputation as mechanicians, fuppofe that it is by means of vibrations of the lips, in the fame manner as in the hautboy, clarionette, and reed pipes of the organ, where the air, fay they, is put in motion by the trembling reed. But this explanation is wrong in all its parts; even in the reed pipes of an organ, the air is *not* put in motion by the reeds. They are indeed the *occafions* of its mufical undulation, but they do not *immediately impel* it into thofe waves. This method (and indeed all methods but the vibrations of wires, bells, &c.) of producing found is little underftood, though it is highly worthy of notice, being the origin of animal voice, and becaufe a knowledge of it would enable the artifts to entertain us with founds hitherto unknown, and thus add confiderably to this gift of our Bountiful Father, who has fhewn, in the ftructure of the larynx of the human fpecies, that he intended that we fhould enjoy the pleafures of mufic as a *laborum dulce lenimen*. He has there placed a micrometer apparatus, by which, *after* the other mufcles have done their part in bringing the glottis nearly to the tenfion which the intended note requires, we can eafily, and inftantly, adjuft it with the utmoft nicety.

We truft, therefore, that our readers will indulge us while we give a very curfory view of the manner in which the tremulous motion of the glottis, or of a reed in an organ pipe, produces the fonorous undulations with a conftant or uniform frequency, fo as to yield a mufical note.

If we blow through a fmall pipe or quill, we produce only a whizzing or hiffing noife. If, in blowing, we fhut the entry with our tongue, we hear fomething like a folid blow or tap, and it is accompanied with fome faint perception of a mufical pitch, juft as when we tap with the finger on one of the holes of a flute when all the reft are fhut. We are then fenfible of a difference of pitch according to the length of the pipe; a longer pipe or quill giving a graver found. Here, then, is like the *beginning* of a fonorous undulation. Let us confider the ftate of the air in the pipe: It was filled by a column of air, which was moving forward, and would have been fucceeded by other air in the fame ftate. This air was therefore nearly in its ftate of natural denfity. When the entry is fuddenly ftopped by the tongue, the included air, already in motion, continues its motion. This it cannot do without growing rarer, and then it is no longer a balance for the preffure of the atmofphere. It is therefore retarded in its motion, totally ftopped (being in a rarefied ftate), and is then preffed back again. It comes back with an accelerated motion, and recovers its natural denfity, while the ftate of rarefaction goes forward through the open air like any other aereal pulfe. Its motions are fomewhat, but not altogether, like that of a fpiral wire, which has been in like manner moving uniformly along the pipe, and has been ftopped by fomething catching hold of its hindermoft extremity. This fpring, when thus catched behind, ftretches itfelf a little, then contracts *beyond* its natural ftate, and then expands again, quivering feveral times. It can be demonftrated that the column of air will make but one quiver. Suppofe this accomplifhed in the hundredth part of a fecond, and that at that inftant the tongue is removed for the hundredth part of a fecond, and again applied to the entry of the pipe. It is plain that this will produce fuch another pulfe, which will join to the former one, and force it out into the air, and the two pulfes together will be like two pulfes produced by the vibration of a cord. If, inftead of the tongue, we fuppofe the flat plate of an organ-reed to be thus alternately applied to the hole and removed, at the exact moments that the renewals of air are wanted, it is plain that we fhall have *fonorous* undulations of *uniform* frequency, and therefore a mufical note. This is the way in which reeds produce

duce their effect, not by *impelling* the air into alternate states of motion to and fro, and alternate strata of rarefied and condensed air, but by giving them time to acquire this state by the combination of the air's elasticity with its progressive motion.

The adjustment of the succeeding puff of air to the pulse which precedes it, so that they may make one smooth and regular pulse, is more exact than we have yet remarked; for the stoppage of the hole not only *occasions* a rarefaction *before it*, but by checking the air which was just going to enter, makes a condensation *behind the door* (so to speak); so that, when the passage is again opened, the two parcels of air are fitted for supporting each other, and forming one pulse.

Suppose, in the next place, that the reed, instead of completely shutting the hole each time, only half shuts it. The same thing must still happen, although not in so remarkable a degree. When the passage is contracted, the supply is diminished, and the air now in the pipe must rarefy, by advancing with its former velocity. It must therefore retard; by retarding, regain its former density; and the air, not yet got into the pipe, must condense, &c. And if the passage be again opened or enlarged in the proper time, we shall have a complete pulse of condensed and rarefied air; and this must be accompanied by the beginning of a musical note, which may be continued like the former.

This will be a softer or more mellow note than the other; for the condensed and rarefied air will not be so suddenly changed in their densities. The difference will be like the difference of the notes produced by drawing a quill along the teeth of a comb, and that produced by the equally rapid vibrations of a wire. For let it be remarked here, that musical notes are by no means confined, as theorists commonly suppose, to the regular cycloidal agitations of air, such as are produced by the vibrations of an elastic cord; but that any crack, snap, or noise whatever, when repeated with sufficient frequency, becomes *ipso facto* a musical sound, of which we can tell the pitch or note. What can be less musical than the solitary cracks or snaps made by a stiff door when very slowly opened? Do this briskly, and the creak changes to a chirp, of which we can tell the note. The sounds will be harsh or smooth, according as the snaps of which they are composed are abrupt or gradual.

This distinction of sounds is most satisfactorily confirmed by experiment. If the tongue of the organ reed is quite flat, and if, in its vibrations, it apply itself to the whole margin of the hole at once, so as completely to shut it (as is the case in the oldfashioned regal stop of the organ), the note is clear, smart, and harsh or hard: but if the lips of the reed are curved, or the tongue properly bent backward, so that it applies itself to the edges of the hole *gradatim*, and never completely shuts the passage, the note may have any degree of mellow sweetness. This remark is worth the attention of the instrument-makers or organ-builders, and enables them to vary the VOICE of the organ at pleasure. We only mention it here as introductory to the explanation of the sounds of the trumpet.

We trust that the reader now perceives how the air, proceeding along a pipe, may be put in the state of alternate strata of condensed and rarefied air, the particles, in the mean time, proceeding along the pipe with a very moderate velocity; while the *state of undulation* is propagated at the rate of eleven or twelve hundred feet in a second; just as we may sometimes see a stream of water gliding gently down a canal, while a wave runs along its surface with much greater rapidity.

It will greatly assist the imagination, if we compare these aereal undulations with the undulations of water in an open canal. While the water is flowing smoothly along, suppose a sluice to be thrust up from the bottom quite to the surface, or beyond it. This will immediately cause a depression on the lower side of the sluice, by the water's going along the canal, and a heaping up of the water on the other side. By properly timing the motion of this sluice up and down, we can produce a series of connected waves. If the sluice be not pushed up to the surface but only one-half way, there will be the same succession of waves, but much smoother, &c. &c.

It is in this state, though not by such means, that the air is contained in a sounding trumpet. It is not brought into this state by any tremor of the lips. The trumpeter sometimes feels such a tremor; but whenever he feels it, he can no longer sound his note. His lips are painfully tickled, and he must change his manner of winding.

When blowing with great delicacy and care, the deepest notes of a French horn, or trombone, we sometimes can feel the undulations of the air in the pipe distinctly fluttering and beating against the lips; and it is difficult to hinder the lips from being affected by it: but we feel plainly, that it is not the lips which are fluttering, but the air before them. We feel a curious instance of this when we attempt to whistle in concert. If our accompanier intonates with a certain degree of incorrectness, we feel something at our own lips which makes it impossible to utter the intended note. This happens very frequently to the person who is whistling the upper note of a greater third. In like manner, the undulations in a pipe react on the reed, and check its vibrations. For if the dimensions of a pipe are such that the undulations formed by the reed cannot be kept up in the pipe, or do not suit the length of the pipe, the reed will either not play at all, or will vibrate only in starts. This is finely illustrated by a beautiful and instructive experiment. Take a small reed of the *vox humana* stop of an organ, and set it in a glass foot, adapted to the windbox of the organ. Instead of the common pipe above it, fix on it the sliding tube of a small telescope. When all the joints are thrust down, touch the key, and look attentively to the play of the reed. While it is sounding, draw out the joints, making the pipe continually longer. We shall observe the reed thrown into strange fits of quivering, and sometimes quite motionless, and then thrown into wide sonorous vibrations, according as the *maintainable* pulse is commensurate or not with the vibrations of the reed. This plainly shews that the air is not impelled into its undulations by the reed, but that the reed accommodates itself to the undulations in the pipe.

We acknowledge that we cannot explain with distinctness in what manner the air in a trumpet is first put into musical undulations. We see that it is only in very long and slender tubes that this can be done. In short tubes, of considerable diameter, like the cowherd's horn, we obtain only one or two very indistinct notes, of which it is difficult to name the pitch; and this requires great force of blast; whereas, to bring out the deep notes of the French horn, a very gentle

and

Musical Trumpet.

and well-regulated blast is necessary. The form of the lips, combined with the force of the blast, form all the notes. But this is in a way that cannot be taught by any description. The performer learns it by habit, and *feels* that the instrument leaps into its note without him, when he gradually varies his blast, and continues sounding the same note; although he, in the mean time, makes some small change in his manner of blowing. This is owing to what Mr Bernoulli observed. The tube is suited only to such pulses, and can only maintain such pulses as correspond to aliquot parts of its length: and when the embouchure is very nearly, but not accurately, suited to a particular note, that note *forms itself* in the tube, and, resting on the lips, brings them into the form which can maintain it with ease. We have a proof of this when we attempt to sound the note corresponding to one seventh of the length. Not having a distinct notion of this note, which makes no part of our scale of melody, we cannot easily prepare for it in the way that habit teaches us to prepare for the others: whereas, from what we shall see presently, the notes *one sixth* and *one eighth* are both familiar to the mind, and easily produced. When, therefore, we attempt to produce the note *one-seventh*, we slide, against our will, into the *one sixth* or *one eighth*.

Nor can we completely illustrate the formation of musical pulses by waves in water. A canal is equally susceptible of every height and length of progressive waves; whereas we see that a certain length of tube will maintain only certain determined pulses of air.

We must therefore content ourselves for the present with having learned, by means of the reed pipes, how the air may exist progressively in a tube, in an alternate state of condensation and rarefaction; and we shall now proceed to consider how this state of the air is related to the length of the tube. And here we can do no more than give an outline of Mr Bernoulli's beautiful theory of flutes and trumpets, but without a mathematical examination of the particular motions. We can, however, shew, with sufficient evidence, how the different notes are produced from the same tube. It requires, however, a very steady attention from the reader to enable him to perceive how the different portions of this air act on each other. We trust that this will now be given.

The conditions which must be implemented, in order to maintain a musical pulse, are two: 1. That the vibrations of the different plates of air be performed in equal times, otherwise they would all mix and confound each other. 2. That they move all together, all beginning and all ending at the same instant. It does not appear that any other state of vibration can exist and be maintained.

The column of air in a tube may be considered as a material spring (having weight and inertia.) This spring is compressed and coiled up by the pressure of the atmosphere. But in this coiled state it can vibrate in its different parts, as a long spiral wire may do, though pressed a little together at the ends. It is evident that the air within a pipe, shut at both ends, may be placed in such a situation, *in a variety of ways*, that it will vibrate in every part, in the same manner as a chord of the same length and weight, strained by a force equal to the pressure of the atmosphere. Thus, in the shut pipe AB (fig. 1.), suppose a harmonic curve ACB, or a wire of the same weight with the air, throwing itself into the form of this curve. The force which impels the point C to the axis is to that which impels the point c as CE to $c\,e$. Now, suppose the air in this pipe divided into parallel strata or plates, crossing the tube like diaphragms. In order that these may vibrate in the same manner (not across the tube, but in the direction of its axis), all that is necessary for the moment is, that the excess of the pressure of the stratum $d\,d$ above that of the stratum $f\,f$ may be to the excess of the pressure of DD above that of FF as $c\,e$ to CE. In this case, the stratum $c\,e$ will be accelerated in the direction $e\,f$, and the stratum EE is accelerated in the same direction, and in the due proportion. Now this may be done in an infinite variety of ways for a single moment. It depends, not on the absolute density, but on the *variation* of density; because the pressure by which a particle of air is urged in any direction arises from the *difference* of the distances of the adjoining particles on each side of it. But in order to *continue* this vibration, or in order that it may obtain at once in the whole pipe, this variation of density must continue, and be according to some connected law. This circumstance greatly limits the ways in which the vibration may be kept up. Mr Bernoulli finds that the isochronism and synchronism can be maintained in the following manner, and in no other that he could think of:

Plate XLV.

Let AB (fig. 2.) be a cylindrical pipe, shut at A, and open at B. Then, in whatever manner the sound is produced in the pipe, the undulations of the contained air must be performed as follows: Let $a\,a$ be a plate of air. This plate will approach to, and recede from, the shut end A, vibrating between the situations $b\,b$ and $c\,c$, the whole vibration being $b\,c$, and the plate will vibrate like a pendulum in a cycloid. The greater we suppose the excursions $a\,b$, $a\,c$, the louder will the sound be; but the duration of them all must be the same, to agree with the fact that the tone remains the same. The motion will be accelerated in approaching to $a\,a$ from either side, and retarded in the recess from it. Let us next consider a plate $\alpha\,\alpha$, more remote from A. It must make similar vibrations from the situation $\beta\,\beta$ to the situation $\gamma\,\gamma$. But these vibrations must be greater in proportion as the plate is farther from A. It cannot be conceived otherwise: For suppose the plate $\alpha\,\alpha$ to make the *same* excursions with $a\,a$, and that the rest do the same. Then they will all retain the same distances from each other; and thus there will be no force whatever acting on any particles to make them vibrate. But if every particle make excursions proportional to its distance from A, the *variation* of density will, in any instant, be the same through the whole pipe, and each particle in the vibrating plate $\beta\,\beta$ will be accelerated or retarded in proportion to its distance from A; while the accelerations and retardations over all will, in any instant, be proportional to the distance of each particle from its place of rest. All this will appear to the mathematician, who attentively considers any momentary situation of the particles. In this manner all the particles will support each other in their vibrations.

It follows from this description that the air in the tube is alternately rarefied and condensed. But these changes are very different in different parts of the tube. They must be greatest of all at A; because, while all the plates approach to A, they concur in condensing the air immediately adjoining to A; while the air in

$a\,a$

$a\,a$ and $\alpha\,\alpha$ is less condensed by the action of the plates beyond it. The air at B is always of its natural density, being in equilibrio with the surrounding air. At B, therefore, there is a small parcel of air, of its natural density, which is alternately going in and out.

This account is confirmed by many facts. If the bottom of the pipe be shut by a fine membrane, stretched across it like a drumhead, with a wire stretched over it, either externally or internally, in the same manner as the catgut is stretched across the bottom of a drum, it will be thrown into strong vibrations, making a very loud noise, by rattling against the cross wire. The same thing happens if the membrane be pasted over a hole close to the bottom, leaving a small space round the edge of the hole without paste, so that the membrane may play out and in, and rattle on the margin of the hole. This also makes a prodigious noise. Now, if the membrane be pasted on a hole far from the bottom, the agitations will be much fainter; and when the hole is near the mouth of the pipe, there will be none. —When a pipe has its air agitated in this manner, it is giving the lowest note of which it is susceptible.

Let us next consider a pipe open at both ends. Let CB (fig. 3) be this pipe. It is plain that, if there be a partition A in the middle, we shall have two pipes AB, AC, each of which may undulate in the manner now described, if the undulations in each be in opposite directions. It is evidently possible, also, that these undulations may be the same in point of strength in both, and that they may begin in the same instant. In this case, the air on each side of the partition will be in the same state, whether of condensation or rarefaction, and the partition A itself will always be in equilibrio. It will perfectly resemble the point C of the musical cord BFCGH (fig. 6.), which is in equilibrio between the vibrating forces of its two parts. In the pipe, the plates of air on each side are either both approaching it, or both receding from it, and the partition is either equally squeezed from both sides, or equally drawn outwards. Consequently this partition may be removed, and the parcels of air on each side will, in any instant, support each other. There seems no other way of conceiving these vibrations in open pipes which will admit of an explanation by mechanical laws. The vibrations of all the plates must be obtained without any mutual hinderence, in order to produce the tone which we really hear; and therefore such vibrations are impressed by Nature on each plate of air.

But if this explanation be just, it is plain that this pipe CB must give the same note with the pipe AB (fig. 2.) of half the length, shut at one end. But the sound, being doubled, with perfect consonance, must be clear, strong, and mellow. Now this is perfectly agreeable to observation; and this fact is an unequivocal confirmation of the justness of the theory. If we take a slender pipe, about six inches long and one half of an inch wide, shut at one end, and sound it by blowing across its mouth, as we whistle on the pipe of a key, or across a hole that is close to the mouth, and formed with an edge like the sound-hole of a German flute, we shall get a very distinct and clear tone from it. If we now take a pipe of double the length, open at both ends, and blow across its mouth, we obtain the same note, but more clear and strong. And the note produced by blowing across the mouth is not changed by a hole made exactly in the middle, in respect of its musical pitch, although it is greatly hurt in point of clearness and strength. Also a membrane at this hole is strongly agitated. All this is in perfect conformity to this mechanism.

Thus we have, in a great measure, explained the effect of an open and a shut pipe. The shut pipe is always an octave, graver than an open pipe of the same length; because the open pipe is in unison with a shut pipe of half the length.

Let AC (fig. 4.) be a pipe shut at both ends. We may consider it as composed of two pipes AB, BC, stopped at A and C, and open at B. Undulations may be performed in each half, precisely as in the pipe AB of fig. 2.; and they will not, in the smallest degree, obstruct each other, if we only suppose that the plates in each half are vibrating at once in the *same* direction. The condensation in AB will correspond with the rarefaction in BC, and the middle parcel B will maintain its natural density, vibrating to, and again across the middle; and two plates $a\,a$, $\alpha\,\alpha$, which are equally distant from B, will make equal excursions in the same direction.

We may produce sound in this pipe by making an opening at B. Its note will be found to be the same with that of BC of fig. 2. or of AB of fig. 2.

In the next place, let a pipe, shut at one end, be considered as divided into any odd number of equal parts, and let them be taken in pairs, beginning at the stopped end, so that there may be an odd one left at the open end. It is plain that each of these pairs may be considered as a pipe stopped at both ends, as in fig. 4.

For the partitions will, of themselves, be in equilibrio, and may be removed, and vibrations may be maintained in the whole, consistent with the vibration of the odd part at the open end; and these vibrations will all support each other, and the plates of air which are at the points of division will remain at rest. Conceive the pipe AB of fig. 2. to be added to the pipe AC of fig. 4. the part A of the first being joined to A of the other. Now, suppose the vibrations to be performed in both, in such a manner that the simultaneous undulations on each side of the junction may be in opposite directions. It is plain that the partition will be in equilibrio, and may be removed; and the plate of air will perform the same office, being alternately the middle plate of a condensed and of a rarefied parcel of air. The two pipes CA, AB will together give the same note that AB would have given alone, but louder.

In like manner may another pipe, equal to AC, be joined to the shut end of this compound pipe, as in fig. 5. and the three will still give the same note that AB would have done alone.

And in the same manner may any number of pipes, each equal to AC, be added, and the whole will give still the same note that AB would have given alone.

Hence it legitimately follows, that if the undulations can be once begun in this manner in a pipe, it may give either the sound competent to it, as a single pipe AB (fig. 2.); or it may give the sound competent to a pipe of $\frac{1}{3}$d, $\frac{1}{5}$th, $\frac{1}{7}$th, &c. of its length; the undulations in each part AB, BC, CD, maintaining themselves in the manner already described. This seems the only way in which they can be preserved, both isochronous and synchronous.

It is known that the gravest tones of pipes are as the lengths

lengths of the pipes, or the frequency of the undulations are inversely as their lengths. (This will be *demonstrated* presently). Therefore these accessory tones should be as the odd numbers 3, 5, 7, &c. and the whole tones, including the fundamental, should form the progression of the odd numbers 1, 3, 5, 7, &c.

This is abundantly confirmed by experiment. Take a German flute, and stop all the finger-holes. The flute, by gradually forcing the blast, will give the fundamental, the 12th, the 17th, the 21st, &c. (A).

Again, let AD (fig. 6.) represent the length of a pipe. Construct on AD an harmonic curve AEBFCGHD, in such a manner that HD may be $\frac{1}{2}$ AB, $= \frac{1}{2}$ BC, $= \frac{1}{2}$ CH The small ordinates *m n* will express the total excursion of the plates of air at the points *m m*, &c. and those ordinates which are above the axis will express excursions on one side of the place of rest, and the ordinates below will mark the excursions in the opposite directions, in the same manner as if this harmonic curve were really a vibrating cord. These excursions are nothing in the points A, B, C, H, and are greatest at the points E, F, G, D, where the little mass of air retains its natural density, and travels to and again, condensing the air at B, or rarefying it, according as the parcels E and F are approaching to or receding from each other. The points A, B, C, H, may be called Nodes, and the parts E, F, G, D, may be called Bights or Loops. This represents very well to the eye the motion of the plates of air. The density and velocity need not be minutely considered at present. It is enough that we see that when the density is increasing at A, by the approach of the parcel E, it is diminishing at B by the recess of E and F; and increasing at C, by the approach of F and G, and diminishing at H, by the recess of G. In the next vibration it will be diminishing at A and C, and increasing at B and H. And thus the alternate nodes will be in the same state, and the adjoining nodes in opposite states.

The reader must carefully distinguish this motion from the undulatory motion of a pulse, investigated by Newton, and described in the article Acoustics, *Encycl.* That undulation is going on at the same time, and is *a result* of what we are now considering, and the cause of our hearing this undulation. The undulation we are now considering is the original agitation, or rather it is the sounding body, as much as a vibrating string or bell is; for it is not the trumpet that we hear, but the air trembling in the trumpet. The trumpet is performing the office, not of the string, but of the pin and bridge on which the string is strained. This is an important remark in the philosophy of musical sounds.

There is yet another set of notes producible from a pipe besides those which follow in the order of frequency 1, 3, 5, 7. &c.

Suppose a pipe open at both ends, sounding by blowing across the end, and undulating, as already described, with a node in the middle A (fig. 3.) If we still express the fundamental note of the pipe AB of fig. 2. by 1, it is plain that the fundamental of an open pipe of the same length will have the frequency of its undulations expressed by 2; because an open pipe of twice the length of AB (fig. 2.) will be 1, the two pipes AB (fig. 2.), and CB (fig. 3.), being in unison.

But this open pipe may be made to undulate in another manner; for we have seen that AB of fig. 2. joined to CA of fig. 4. may sound altogether when the partition A is removed, still giving the note of AB (fig. 2.) Let such another as AB (fig. 2.) be added to the end C, and let the partition be removed. The whole may still undulate, and still produce the same note; that is, a pipe open at both ends may sound a note which is the fundamental of a pipe like AB (fig. 2.), but only one-fourth of its length. The pipe CB of fig. 3. may thus be supposed to be divided into four equal parts, CE. EA, AF, FB, of which the extreme parts EC and FB contain undulations similar to those in AB (fig. 2.); and the two middle parts contain undulations like those in CA (fig. 4.) The partitions at E and F may be removed, because the undulations in EC and EA will support each other, if they are in opposite directions; and those in FB and FA may support each other in the same manner.

It must here be remarked, that in this state of undulation the direction of the agitations at the two extremities is the same; for in the middle piece EF the particles are moving one way, condensing the air at E, while they rarefy it at F. Therefore, while the middle parcel is moving from E towards F, the air at B must be moving towards F, and the air at C must be moving from E. In short, the air at the two extremities must, in every instant, be moving in the opposite direction to that of the air in the middle.

In like manner, if the pipe CB of fig. 3. be divided into six parts, the two extreme parts may undulate like AB of fig. 2. and the four inner parts may undulate like two pipes, such as CA of fig. 4. and the whole will give the sound which makes the fundamental of a pipe of one-sixth of the length, or having the frequency 6.

We may remark here, that the simultaneous motion of the air at the extremities is in opposite directions, whereas in the last case it was in the same direction. This is easily seen; for as the partition which is between the two middle pieces must always be in equilibrio, the air must be coming in or going out at the extremities

(A) A little reflection will teach us that these tones will not be perfectly in the scale. A certain proportion between the diameter and length of the pipe produces a certain tone. Making the pipe wider or smaller flattens or sharpens this tone a little, and also greatly changes its clearness. Organ-builders, who have tried every proportion, have adopted what they found best. This requires the diameter to be about $\frac{1}{11}$th or $\frac{1}{12}$th of the length. Therefore, when we cause the same pipe to sound different notes, we neglect this proportion; and the notes are false, and even very coarse, when we produce one corresponding to a very small portion of the pipe. For a similar reason, Mr Lambert found that, in order to make his pitch-pipe sound the octave to any of its notes, it was not sufficient to shorten its capacity one-half by pushing down the piston; he found that the part remaining must be less than the part taken off by a fixed quantity $1\frac{5}{11}$ inches. Or, the length which gave any note being x, the length for its octave must be $\frac{x - 1\frac{5}{11}}{2}$.

tremities together. This circumstance must give some sensible difference of character to the sounds 4 and 6. In the one, the agitations at each end of the tube are in the same direction, and in the other they are in the opposite. Both produce pulses of sound which are conveyed to the ear. Thus we see that the air in a pipe open at both ends may undulate in two ways. It may undulate with a node in the middle, giving the note of AB (fig. 2.), or of its 3d, 5th, 7th, &c. part; and it may undulate with a loop or bight in the middle, sounding like $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{6}$, &c. of AB, fig. 2.

In like manner may this pipe produce sounds whose frequency are expressed by 8, 10, &c. and proceed as the even numbers.

This state of agitation may be represented in the same way that we represented the sounds 1, 3, 5, &c. by constructing on AM (fig. 7.) an harmonic curve, with any number of nodes and loops. Divide the parts AF, FD, DE, EM, equally in C, O, P, B. CB will correspond to the pipe, and the ordinates to the curve GFHDLEN will express the excursions of the plates of air.

If the pipe gives its fundamental note, its length must be represented by CO, and the undulations in it will resemble the vibrations of part CO of a cord, whose length AD is equal to 2CO, and which has a node in F.

If the pipe is sounding its octave, it will be represented by CP, and its indulations will resemble the vibrations of a cord CP, whose length AE is $\frac{3}{2}$ of CP, having nodes at F and D, &c. &c.

We can now see the possibility of such undulations existing in a pipe as will be permanent, and produce all the variety of notes by a mere change in the manner of blowing, and why these notes are in the order of the natural numbers, precisely as we observe to happen in winding the trumpet or French horn. We have, *1st*, the fundamental expressed by 1; then the octave 2; then the 12th, 3; the double octave 4; then the third major of that octave 5, or 17th of the fundamental; then the octave of the 12th, or the 5th of this double octave, = 6. We then jump to the triple octave 8, without producing the intermediate sound corresponding to $\frac{1}{7}$th of the pipe. With much attention we can hit it; and it is a fact that a person void of musical ear stumbles on it as easily as on any other. But the musician, finding this sound begin with hum, and his ear being grated with it, perhaps thinks that he is mistaking his embouchure, and he slides into the octave. After the triple octave, we easily hit the sounds corresponding to $\frac{1}{9}$ and $\frac{1}{10}$, which are the 2d and 3d of this octave. The next note $\frac{1}{11}$ is sharper than a just 4th. We easily produce the note 12, which is a just 5th; 13 is a false 6th; 14 is a sound of no use in our music, but easily hit; 15 and 16 give the exact 7th and 8th of this octave.

Thus, as we ascend, we introduce more notes into every octave, till at last we can nearly complete a very high octave; but in order to do this with success, and tolerable readiness, we must take an instrument of a very low pitch, that we may be able nearly to fill up the steps of the octave in which our melody lies. Few players can make the French horn or trombone sound its real fundamental, and the octave is generally mistaken for it. The proof of this is, that most players can give the 5th of the lowest note that they are able to produce; whereas the 5th of the real fundamental cannot be uttered. Therefore that lowest note is not the fundamental, but the octave to the fundamental.

Few performers can sound even this second octave on a short instrument, such as the ordinary military trumpet; and what they imagine to be the fundamental sound of this instrument is the double octave above it. This appears very strange; and it may be asked, how we know what is really the fundamental note of a trumpet? The answer to this is to be obtained only by demonstrating, on mechanical principles, what is the frequency of undulation corresponding to a given length of pipe. This is a proposition equally fundamental with its corresponding one in the theory of musical cords; but we have reserved it till now, because many readers would stop short at such an investigation, who are able to understand completely what we have now delivered concerning the music of the trumpet.

Suppose therefore a pipe shut at both ends, and that the whole weight of the contained air is concentrated in its middle point, the rest retaining its elasticity without inertia; or (which is a more accurate conception), let the middle point be conceived as extending its elasticity to the two extremities of the pipe, being repelled from each by a force inversely as the distance. Let the length of this pipe be L. This may also express the weight of the middle plate of air, which will always be proportional to the length of the pipe, because all is supposed to be concentrated there. Let E be the elasticity of the air. This must be measured by the pressure of the atmosphere, or by the weight of the column of mercury in the barometer. Perhaps the rationale of this will be better conceived by some readers by considering E as the height of a homogeneous atmosphere. Then it is plain that E is to L as the weight of this atmospheric column to the weight of the column of the same air which fills the pipe whose length is L. Then it is also plain that E is to L as the external pressure; and consequently, as the elasticity which supports that pressure is to the weight or inertia of the matter to be moved. Let this middle plate or diaphragm be withdrawn from its place of rest to the very small distance a. The elasticity or repulsion will be augmented on one side and diminished on the other; and the difference between them is the only force which impels the diaphragm toward the middle point, and causes it to vibrate, or produces the undulation. It is plain that the repulsion on one side is $\frac{\frac{1}{2}\mathrm{L}}{\frac{1}{2}\mathrm{L}-a}\times\mathrm{E}$, or $\frac{\mathrm{L}}{\mathrm{L}-2a}\,\mathrm{E}$ $\left(\text{for } \frac{1}{2}\mathrm{L}-a : \frac{1}{2}\mathrm{L} = \mathrm{E} : \frac{\frac{1}{2}\mathrm{LE}}{\frac{1}{2}\mathrm{L}-a}\right)$, and the repulsion on the other side is $\frac{\frac{1}{2}\mathrm{L}}{\frac{1}{2}\mathrm{L}+a}\times\mathrm{E}$, or $\frac{\mathrm{L}}{\mathrm{L}+2a}\,\mathrm{E}$. The difference of these repulsions is $\mathrm{E}\times\mathrm{L}\times\frac{4a}{\mathrm{L}^2-4a^2}$. But as we suppose a exceedingly small in comparison with L, this difference, or the accelerating force, may safely be expressed by $\mathrm{E}\,\frac{4a}{\mathrm{L}}$, or $4a\,\frac{\mathrm{E}}{\mathrm{L}}$.

Hence we deduce, in the first place, that the undulations will be isochronous, whether wide or narrow; because the accelerating force is always proportional to the distance a from the middle point.

Now,

Musical Trumpet.

Now, let a pendulum, whose quantity of matter is L, and length a, be supposed to vibrate in a cycloid by the force $\frac{4a}{L}$ E, or $\frac{4E}{L}a$. It must perform its vibrations in the same time with the plate of air; because the moving force, the matter to be moved, and the space along which they are to be similarly impelled, are the same in both cases. Let another pendulum, having the same quantity of matter L, vibrate by its weight L alone. In order that these two pendulums may vibrate in equal times, their lengths must be as the accelerating forces. Therefore we must have $\frac{4E}{L}a : L = a : \frac{aL^2}{4Ea}, = \frac{L^2}{4E}$, which is therefore the length of the synchronous pendulum.

Now, a cord without weight and inertia, but loaded with the weight L at its middle point, and strained by a weight E, and drawn from the axis to the distance a, is precisely similar in its motion to the diaphragm we are now considering, and must make its oscillations in the same time.

This is applicable to any number of plates of air, by substituting in the cord a loaded point for each of the plates; for when the case is thus changed, both in the pipe and the cord, the space to be passed over by the plate of air bears the same proportion to a, which is passed over by the whole air concentrated in the middle point, which the space to be passed over by the corresponding loaded point of the cord bears to that passed over by the whole matter of the cord concentrated in the middle point; and the same equality of ratios obtains in the accelerating forces of the plate of air and the corresponding loaded point of the cord. Suppose, then, a pipe divided into 2, 3, 4, &c. equal parts, by 1, 2, 3, diaphragms, each of which contains the air of the intervening portion of the pipe, the whole weight L being equally divided among them. If there be but one diaphragm, its weight must be L; if two, the weight of each must be $\frac{1}{2}$ L; if three, the weight of each must be $\frac{1}{3}$ L; and so on for any number.

By considering this attentively, we may infer, without farther investigation, what will be the undulations of all the different plates of air in a pipe stopped at both ends. We have only to compare it with a cord similarly divided and loaded. Increase the number of loaded points, and diminish the load on each, continually—it is evident that this terminates in the case of a simple cord, with its matter uniformly diffused; and a simple pipe, with its air also uniformly diffused over its whole length.

Therefore, if we take an elastic cord, and stretch it by such a weight that the extending weight may bear the same proportion to the accelerating force acting on the whole matter concentrated in its middle point, which the elasticity of the air bears to its accelerating force acting on the whole matter concentrated at the mouth of an open pipe, sounding its fundamental note, the cord and the air will vibrate in the same time. Moreover, since the proportion between the vibrations of a cord so constituted, and those of a cord having its matter uniformly diffused, is the same with the proportion between the undulations in a pipe so constituted, and those of a pipe in which the air is uniformly diffused—it is plain that the vibrations of the cord and of the pipe in their natural state will also be performed in equal times.

We look on this as the easiest way of obtaining a distinct perception of the authority on which we rest our knowledge of the absolute number of undulations of the air in a pipe of given length. It may be obtained directly; and Daniel Bernoulli, Euler, and others, have given very elegant solutions of this problem, without having recourse to the analogy of the vibrations of cords and undulations of a column of air But it requires more mathematical knowledge than many readers are possessed of who are fully able to follow out this analogical investigation.

Let us therefore compare this theory with experiment. What we call an open pipe of an organ is the same which we, in this theory, have considered as a pipe open at both ends; for the opening at the foot, which the organ-builders call the VOICE of the pipe, is equivalent to a complete opening. The aperture, and the sharp edge which divides the wind, may be continued all round, and the wind admitted by a circular slit, as is represented in fig. 10. We have tried this, and it gives the most brilliant and clear tones we ever heard, far exceeding the tones of the organ. An open organ pipe, therefore, when sounding its fundamental note, undulates with one node in its middle, and its undulations are analogous, in respect of their mechanism, with the vibrations of a wire of the same length, and the same weight, with the column of air in the pipe, and stretched by a weight equal to that of a column of the same air, reaching to the top of a homogeneous atmosphere, or equal to the weight of a column of mercury as high as that in the barometer.

Dr Smith (see *Harmonics*, 2d edit. p. 193.) found that a brass wire, whose length was 35,55 inches, and weight 31 troy grains, and stretched by 7 pounds avoirdupois, or 49000 grains, was in perfect unison with an open organ pipe whose length was 86,4 inches.

Now 86,4 inches of this wire weighs 75,34 grains. When the barometer stands at 30 inches, and the thermometer at 55° (the temperature at the time of the experiment), the height of a homogeneous atmosphere is 332640 inches. This has the same proportion to the length of the pipe which the pressure of the atmosphere has to the weight of the column of air contained in the pipe.

Now 86,4 : 332640 = 75,34 : 290060. This wire, therefore, should be stretched (if the theory be just) by 290060 grains, in order to be unison with the other wire, and we should have $35{,}55^2 : 86{,}4^2 = 49000 : 290060$

But, in truth, . $35{,}55^2 : 86{,}4^2 = 49000 : 289430$

The difference is 630

The error scarcely exceeds $\frac{1}{500}$, and does not amount to an error of one vibration in a second.

We must therefore account this theory as accurate, seeing that it agrees with experiment with all desirable exactness.

We may also deduce from it a very compendious rule for determining the absolute number of aereal pulses made by an open pipe of any given length. When considering the vibrations of cords, we found that the number of vibrations made in a second is $\sqrt{\frac{386\,E}{LW}}$, where E is the extending weight, W the weight of the cord, and L its length. Let H be the height of a homogeneous

neous atmosphere. We have its weight $= \frac{HW}{L}, = E$. Therefore substituting $\frac{HW}{L}$ for E in the above formula, we have the number of aerial pulses made per second $= \sqrt{\frac{386 H}{L^2}}$, or $= \frac{\sqrt{386 H}}{L}$. Now $\sqrt{386 H}$, computed in inches, is 11331. Therefore, if we also measure the length of the pipe L in inches, the pulses in a second are $= \frac{11331}{L}$. Thus, in the case before us, $\frac{11331}{86,4} = 131,12$, or this pipe produces 131 pulses in a second. Dr Smith found by experiment that it produced 130,9, differing only about $\frac{1}{5}$th of a pulse.

We see that the pitch of a pipe depends on the height of the homogeneous atmosphere. This may vary by a change of temperature. When the air is warmer it expands, and the weight of the induced column is lessened, while it still carries the same pressure. Therefore the pitch must rise. Dr Smith found his organ a full quarter tone higher in summer than in winter. The effect of this is often felt in concerts of wind instruments with stringed instruments. The heat which sharpens the tone of the first flattens the last. The harpsichord soon gets out of tune with the horns and flutes.

Sir Isaac Newton, comparing the velocity of sound with the number of pulses made by a pipe of given length, observed that the length of a pulse was twice the length of the open pipe which produced it. Divide the space passed over in a second by the number of pulses, and we obtain the length of each pulse. Now it was found that a pipe of 21,9 inches produced 262 pulses. The velocity of sound (as computed by the theory on which our investigation of the undulations in pipes proceeds) is 960 feet. Now $\frac{960 \times 12}{262} = 44$ inches very nearly, the half of which is 22, which hardly differs from 21,9. The difference of this theoretical velocity of sound, and its real velocity 1142 feet per second, remains still to be accounted for. We may just observe here, that when a pipe is measured, and its length called 21,9, we do really allow it too little. The voice-hole is equivalent to a portion, not inconsiderable of its length, as appears very clearly from the experiments of Mr Lambert on a variable pitch-pipe, and on the German flute, recorded in the Berlin Memoirs for 1775. He found it equivalent to $\frac{1}{5}$th; and this is sufficient for reconciling these measures of a pulse with the real velocity of sound.

The determination which we have given of the undulations of air in an organ pipe is indirect, and is but a sketch of the beautiful theory of Daniel Bernoulli, in which he states with accuracy the precise undulation of each plate of air, both in respect of position, density, velocity, and direction of its motion. It is a pleasure to observe how the different equations coincide with those which express the vibrations of an elastic cord. But this would have taken up much room, and would not have been suited to the information of many curious readers, who can easily follow the train of reasoning which we have employed.

Mr Bernoulli applies the same theory to the explanation of the undulations in flutes, or instruments whose sounds are modified by holes in the sides of the pipe. But this is foreign to our purpose of explaining the music of the trumpet. We shall only observe, that a hole made in that part of a pipe where a node should form itself, in order to render practicable the undulations, competent to a particular note, prevents its formation, and in its place we only get such undulations (and their corresponding sounds) as have a loop in that place. The intelligent reader will perceive that this single circumstance will explain almost every phenomenon of flutes with holes; and also the effects of holes in instruments with a reed voice, such as the hautboy or clarionette.

We now see that the sound or musical pitch of a pipe is inversely as its length, in the same manner as in strings, And we learn, by comparing them, that the sound of a trumpet has the same pitch with an open organ pipe of the same length. A French horn, 16 feet long, has the sound C *fa ut*, which is also the sound of an open flute-pipe of that length.

The TROMBONE, great trumpet, or SACKBUT, is an old instrument described by Mersennus and other authors of the last century. It has a part which slides (air-tight) within the other. By this contrivance the pitch can be altered by the performer as he plays. This is a great improvement when in good hands; because we can thus correct all the false notes of the trumpet, which are very offensive, when they occur in an emphatical or holding note of a piece of music. We can even employ this contrivance for filling up the blanks in the lower octaves.

We must not take leave of this subject without taking notice of another discovery of Mr Bernoulli's, which is exceedingly curious, and of the greatest importance in the philosophy of music.

Artists had long ago observed that the deep notes of musical instruments are sometimes accompanied by their harmonic sounds. This is most clearly perceived in bells, some of which give these harmonics, particularly the 12th, almost as strong as the fundamental. Musicians, by attending more carefully to the thing, seem now to think that this accompaniment is universal. If one of the finest sounding strings of the bases of a harpsichord be struck, we can hear the 12th very plainly as the sound is dying away, and the 17th major is the last sound that dies away on the ear. This will be rendered much more sensible, if we divide the wire into five parts, and at the points of division tie round it a thread with a fast knot, and cut the ends off very short. This makes the string false indeed by the unequal loading; but, by rendering those parts somewhat less moveable by this additional matter, the portions of the wire between these points are thus jogged, as it were, into secondary vibrations, which have a more sensible proportion to the fundamental vibration. This is still more sensible in the sound of the strings of a violincello when so loaded; but we must be careful not to load them too much, because this would so much retard the fundamental vibration, without retarding the secondary vibrations, that both cannot be maintained together. (*N. B.* This experiment always produces a beat in the sound).—Listening to a fine sounding flute-pipe of the organ, we can also very often perceive the same thing. Mr Rameau, and most other theorists in music, now assert fert that this is the effence of a mufical found, and *neceffarily* exifts in all of them, diftinguifhing them from harfh noifes. Rameau has made this the foundation of his fyftem of mufic, afferting that the pleafure of harmony refults from the fuccefsful imitation of this harmony of Nature, (fee Music, *Encycl.*). But a little logic fhould convince thefe theorifts that they muft be miftaken. If a note is mufical becaufe it has thefe accompaniments, and by this compofition alone is a mufical note, what are thefe harmonics? Are they mufical notes? This is granted. Therefore they have the fame compofition; and a mufical note muft confift at once of every poffible found; yet we know that this would be a jarring noife. A little mathematics, too, or mechanics, would have convinced them. A fimple vibration is furely a moft poffible thing, and therefore a fimple found. No, fay the theorifts; for though the vibration of the cord may be fimple, it produces fuch undulations in the air as excite in us the perception of the harmonics. But this is a mere affertion, and leaves the queftion undecided. Is not a fimple undulation of the air as poffible as the fimple vibration of a cord?

It is, however, a very curious thing, that almoft all mufical founds really have this accompaniment of the octave, 12th, double octave, and 17th major; for thefe are the harmonics that we hear.

The jealoufy of Leibnitz and of John Bernoulli, and their unfriendly thoughts refpecting all the Britifh mathematicians, made John Bernoulli do every thing in his power to leffen the value of Dr Taylor's inveftigation of the vibration of a mufical cord. Taylor gave him a good opportunity. Perhaps a little vain of his inveftigation of this abftrufe matter, he thought too much of it. He affirmed that the harmonic curve was the effential form of a ftring giving a mufical note. This was denied, without knowing at firft whether it was true or falfe. But as the analytic mathematics improved, it was at length found that there are an infinity of forms into which an elaftic cord can be thrown, which are confiftent both with ifochronous vibrations, whether wide or narrow, and alfo with the condition of the whole cord becoming a ftraight line at once. Euler, D'Alembert, and De la Grange, have profecuted this matter with great ingenuity, and it is one of the fineft problems of the prefent day.

Daniel Bernoulli, of a very different caft of mind from his illuftrious friends, admired both Newton and Taylor; and fo far from wifhing to eclipfe Dr Taylor by the additions he had made to his theory, tried whether he could not extend Taylor's doctrine as far as the author had faid. When he took a review of what he had done while explaining the partial vibrations of mufical cords, he thought it very poffible that while a cord is vibrating in three portions, with two nodes or points of reft, and founding the 12th to its fundamental, it might at the fame time be alfo vibrating as a fimple cord, and founding its fundamental note. It was poffible, he thought, that the three portions might be vibrating between the four points with a triple frequency, while the two middle nodes were vibrating acrofs the ftraight line between the two pins; and thus the vibrating cord might be a moveable axis, to which the rapid vibrations of the three parts might always be referred. This was very fpecious; and when a little more attentively confidered, became more probable: for if the cord $A p B q C r D$ (fig. 8.) be vibrating as a 12th to its fundamental AD, the points B and C are in equilibrio. If therefore thefe two points be laid hold of by hooks, and be drawn afide to β and γ, while the ftring is yet vibrating, this fhould not hinder the vibrations. If the hooks be annihilated in an inftant, the whole fhould vibrate between A and D; and this fhould be in a way very different from the fimple vibration. The queftion now is, will the cord *continue* to vibrate with the loops $\beta s \gamma$, $\beta q \gamma$, &c. in the 900th part of a fecond (for inftance), while the whole ftring vibrates from $A \beta \gamma D$ to $A \beta' \gamma' D$ in the 300th part of a fecond? or will it at once acquire the form of the fimple harmonic curve? The cafe in which it is moft likely to take the latter mode of vibration is when the points β and γ are let go at the inftant that each portion of the ftring is in the middle of its vibration, and therefore forms the line $A \beta \gamma D$. But a moment's confideration will fhew us that it cannot do this; for at that inftant the point v, for inftance, which had come from q, is moving outwards with a moft rapid motion, and therefore will continue to go outward, while β and γ are approaching the axis. The point w, on the contrary, is at this moment approaching the axis with a motion equally rapid. They cannot therefore all come to the axis at once, and the vibration muft differ greatly from a fimple one. On the other hand, let it be fuppofed that both fpecies of vibrations can be preferved, and that, at the moment of letting go the points β and γ, the cord has the form $A\, m\, \beta\, q\, \gamma\, n\, D$. Then, when β and γ have come to B and C, having made $\frac{1}{2}$ a vibration, the point m will be in the axis, having made a vibration downward, and a half vibration upwards, q, in like manner, is in the axis, having made a whole vibration upwards, and half a vibration downwards. n is like m. Thus the whole comes to the axis at once; and in fuch a manner, that if the points B and C were inftantly ftopped, the three portions would continue their partial vibrations without any new effort. The refult of this compound vibration muft be a compound pulfe of air, which will excite in us the perception of the fundamental found and of its 12th. The confequence will be the fame if the points β and γ are ftopped any where fhort of the axis; and therefore (faid Bernoulli) the ftring will really vibrate fo if not ftopped at all.

But this was refufed by Euler, who obferved that in the points β and γ of contrary flexure, having no curvature, there can be no accelerating force. This caufed Bernoulli to attempt a direct inveftigation, examining minutely the curvatures and accelerating forces in the different points.

He had the pleafure of finding that the accelerating forces arifing from the curvature in every point, were precifely fuch as would produce the accelerations neceffary in thofe points for performing the motion that was required. And he exhibited the equations expreffive of the ftate of the cord in all thefe points. And, on the faith of thefe equations, he reftored the Taylorean curve to the rank which its inventor had given it; and he afferted that in every mufical vibration the cord was difpofed in a harmonical curve either fimple or compound. He farther fhewed that the equations which Euler and D'Alembert had given for the mufical cord (at leaft in the cafes which they had publifhed)

Musical Trumpet.

ed) were included in his equations, and that their equations only exhibited its momentary ftates, while his own equations fhewed the phyfical connection of them all; which is, that the whole cord forms a harmonic curve between the two fixed pins, while its different portions form fubordinate harmonic curves on the firft as an axis Euler and D'Alembert, although they acknowledge this in the particular cafes which they had taken as examples, on account of their fimplicity, ftill infift that no fubordinate harmonic vibrations can correfpond to all the ftates of an elaftic cord which their equations exhibit as ifochronous and permanent. Mr Bernoulli's death put an end to the controverfy, and the queftion (confidered as a general theory) is perhaps ftill undecided. It may very probably be true, that as a fimple vibration may be permanent which never has the form of the fimple harmonic defcribed by Dr Taylor, fo a vibration may exift compounded of fuch vibrations, and therefore not expreffible by any equation deduced from the Taylorean curve.

But, in the mean time, Mr Bernoulli has made the moft beautiful difcovery in mechanics which has appeared in the courfe of the laft century, and has explained the moft curious phenomenon of continued founds, *viz.* the *almoft univerfal* accompaniment of the harmonic notes of any fundamental found. For this *fufceptibility* of compounded variation is not confined to a 12th, but is equally demonftrable of every other harmonic. Nay, it is evident that the fame fimple vibration of a cord may furnifh a moveable axis to more than one harmonic. For as the fimple vibration can have a fubordinate harmonic vibration fuperinduced upon it, fo may this compounded vibration have another fuperinduced on it, and fo on to any degree of compofition. And farther, as Mr Bernoulli has fhewn the complete analogy between the accelerations of the different points of an elaftic cord and of the correfponding plates of a column of air, it legitimately follows that all the confequences which we can eafily deduce, refpecting the vibrations of an elaftic cord, may be affirmed refpecting the undulations of a column of air in a pipe. Therefore this accompaniment of the harmonics muft not be confined to the mufic of ftrings and bells, but equally obtains in the mufic of wind inftruments. And thus the doctrine becomes univerfal.

Mr Bernoulli did not think it enough to fhew that thefe compound vibrations are poffible. He endeavours to fhew that this accompaniment muft be frequent. He illuftrates this very prettily, by fuppofing that a toothed wheel is turned round, and rubs with its teeth on an elaftic cord. If the fucceffive dropping of the teeth keep exactly pace with fuch vibrations as the cord can take and maintain by its elafticity, thefe will certainly be formed on it. If the intervals do not *exactly* correfpond, a little reflection will fhew that the agitation which the cord acquires will approximate to thofe which it can maintain; and, if when they are exactly fo in any place of it, and the wheel be in that inftant removed, this vibration will remain and diffufe itfelf through the reft of the cord; fo that the very laft dying quiver (fo to fpeak) will be a harmonic. Every *harmonic* agitation tends, by the very nature of the thing, to continue, while thofe that are incompatible really *do* deftroy each other; and the very laft muft be the remainder or fuperplus of fuch as could continue, over thofe which deftroyed each other. Accordingly, the harmonic notes of wires are always moft diftinctly heard as the found is dying away.

There is no occafion now to fay any thing about the fallacy of Rameau's *Generation Harmonique* as a theory of mufical pleafure. Our harmonics pleafe us, not becaufe a found is accompanied by its harmonics, but becaufe harmonics pleafe. His principle is therefore a tautology, and gives no inftruction whatever. His theory is a very *forced* accommodation of this principle to the practice of muficians, and tafte of the Public. He is exceedingly puzzled in the cafe of the *foufdominante*, or 4th of the fcale, and the 6th where there is no refonnance. He fays that thefe notes, "fremiffent, quoiqu' elles ne refonnent pas." But this mifleads us. They do not refound; becaufe a 4th and 6th cannot be produced at all by dividing the cord. They tremble; becaufe the falfe 4th and falfe 6th are very near the true ones, and the true 4th and 6th would both tremble and refound, if they were made falfe. A ftring will both tremble and refound, if very nearly true, as any one obferves the 12th and 17th on a harpfichord tremble and refound very ftrongly, though they are tempered notes. The whole theory is overturned at once by tuning the 4th falfe, fo as to correfpond to an aliquot divifion of the cord. It will then refound; and if this had happened to be agreeable, it would have been catched at as the foufdominante.

The phyfical caufe of the pleafure of harmonic founds is yet to feek, as much as our choice of thofe notes for melody which give us the beft harmony (fee Temperament, *Suppl.*). We have no hefitation in faying that, with refpect to our choice, the two are quite independent. Thoufands enjoy the higheft pleafure from melody who never heard a harmonious found. All the untaught fingers, and all fimple nations, are examples.

They not only fix on certain intervals as the fteps of their tunes, but are difgufted when other fteps are taken. Nor do we hefitate, for the very fame reafons, to fay that the rules of accompaniment are dependent on the cantus or air, and by no means on the fundamental bafs of Rameau. The dependence affumed by him, as the rule of accompaniment, would, if properly adhered to, according to his own notions of the comparative values of the harmonics, lead to the moft fantaftic airs imaginable, always jumping by large intervals, and altogether incompatible with graceful mufic. The rules of modulation which he has fqueezed out of his principle, are nothing but forced, very forced, accommodations of a very vague principle to the current practice of his contemporaries. They do not fuit the primitive melodies of many nations, and they have caufed thefe national mufics to degenerate. This is acknowledged by all who are not perverted by the prevailing habits. We have heard, and could write down, fome moft enchanting lullabies of fimple peafant women, poffeffed of mufical fenfibility, but far removed, in the cool fequeftered vale of life, from all opportunities of ftealing from our great compofers. Some of thefe lullabies never fail to charm, even the moft erudite mufician, when fung by a fine flexible voice: but it would puzzle Mr Rameau to accompany them *fecundum artem*.

We conclude this fubject by defcribing a moft beautiful and inftructive experiment.

Mr Watt, the celebrated engineer, was amufing himfelf

Musical Trumpet.

self (about the year 1765) with organ-building, and invented a monochord of continued sound, by which he could tune an organ with mathematical precision, according to any proposed system of temperament. It consisted of a covered string of a violincello, sounding by the friction of an ivory wheel. The instrument did not answer Mr Watt's purpose, by reason of the dead harshness of its tone, and a flutter in the string by the unequal action of the wheel. But Mr Watt was amused by observing the string frequently taking, of its own accord, points of division, which remained fixed, while the rest was in a state of strong vibration. The instrument came into the possession of the writer of this article. He soon saw that it gave him an opportunity of making all the experiments which Bernoulli could only relate. When the string was kept in a state of simple vibration, by a very uniform and gentle motion of the wheel, if its middle point was then gently touched with a quill, this point immediately stopped, but the string continued to vibrate in two parts, sounding the octave: And this it continued to do, however strong the vibrations were rendered afterwards by increasing the pressure and velocity of the wheel. The same thing happened if the string was gently touched at one third. It instantly divided itself into three parts, with two nodes, and sounded the 12th. In the same manner the double octave, the 17th, and all other harmonics, were produced and maintained.

But the prettiest experiment was to put something soft, such as a lock of cotton, in the way of the wide vibrations of the cord, at one-third and two-thirds of its length, so as to disturb them when they became very wide. When this was done, the string instantly put on the appearance of fig. 8. performing at once the full vibration competent to its whole length, and the three subordinate vibrations, corresponding to one-third of its length, and sounding the fundamental and the 12th with equal strength. In this manner all the different accompaniments were produced at pleasure, and could be continued, even with strong sounds. And it was amusing to observe, when the wheel was strongly pressed to the string, and the motion violent, the nodes would form themselves on various parts of the string, running from one part to another. This was always accompanied with all the jarring sounds which corresponded to them.

When the string was making very gentle, simple vibrations, and the wheel hardly touching it, if a violincello was made to sound the 12th very strongly in its neighbourhood, the string instantly divided itself, and vibrated in unison, frequently retaining its simple vibration and fundamental tone. We recommend this experiment to every person who wishes to make himself well acquainted with the mechanism of musical sounds. He will see, in a most sensible and convincing manner, how a single string of the Æolian harp gives us all the changes of harmony, sliding from one sound to another, according as it is affected in its different parts by an irregular breeze of wind. The writer of this article has attempted to regulate these sweet harmonic notes, and to introduce them into the organ. His success has been very encouraging, and the sounds far exceed in pathetic sweetness any that have yet been produced by that noble instrument. But he has not yet brought them fully under command, nor made them strong enough for any thing but the softest chamber music. Other necessary occupations prevent him from giving the attention to this subject that it deserves. He recommends it therefore to the musical instrument-makers as richly deserving their notice. His general method was this: A wooden pipe is made, whose section is a double square. A partition in the middle divides it into two pipes, along side of each other. One of them communicates with the foot and wind chest, and is shut at the upper end. The other is open at the upper, and shut at the lower end. In the partition there is a slit almost the whole length, and the sides of this slit are brought to a very smooth chamfered or feather edge. A fine catgut is strained in this slit, so as almost to touch the sides. It is evident that when the wind enters one pipe by the foot, it passes through the slit into the other, and escapes at the top, which is open. In its passage it forces the catgut into motion, and produces a musical note, having all the sweetness of the Æolian harp. The strength of sound may be increased by increasing the body of air which is made to undulate. This was done by using, instead of catgut, very narrow silk tape or ribband varnished: but the unavoidable raggedness of the edges made the sounds coarse and wheezing. Flat silver wire was not sufficiently elastic; flat wire, used for watch balance springs, was better, but still very weak sounded. Other methods were tried, which promised better. A thin round plate of metal, properly supported by a spring, was set in a round hole; made in another plate not so thin, so as just not to touch the sides. The air forced through this hole made the spring plate tremble, dancing in and out, and produced a very bold and mellow sound.—This, and similar experiments, are richly worth attention, and promise great additions to our instrumental music.

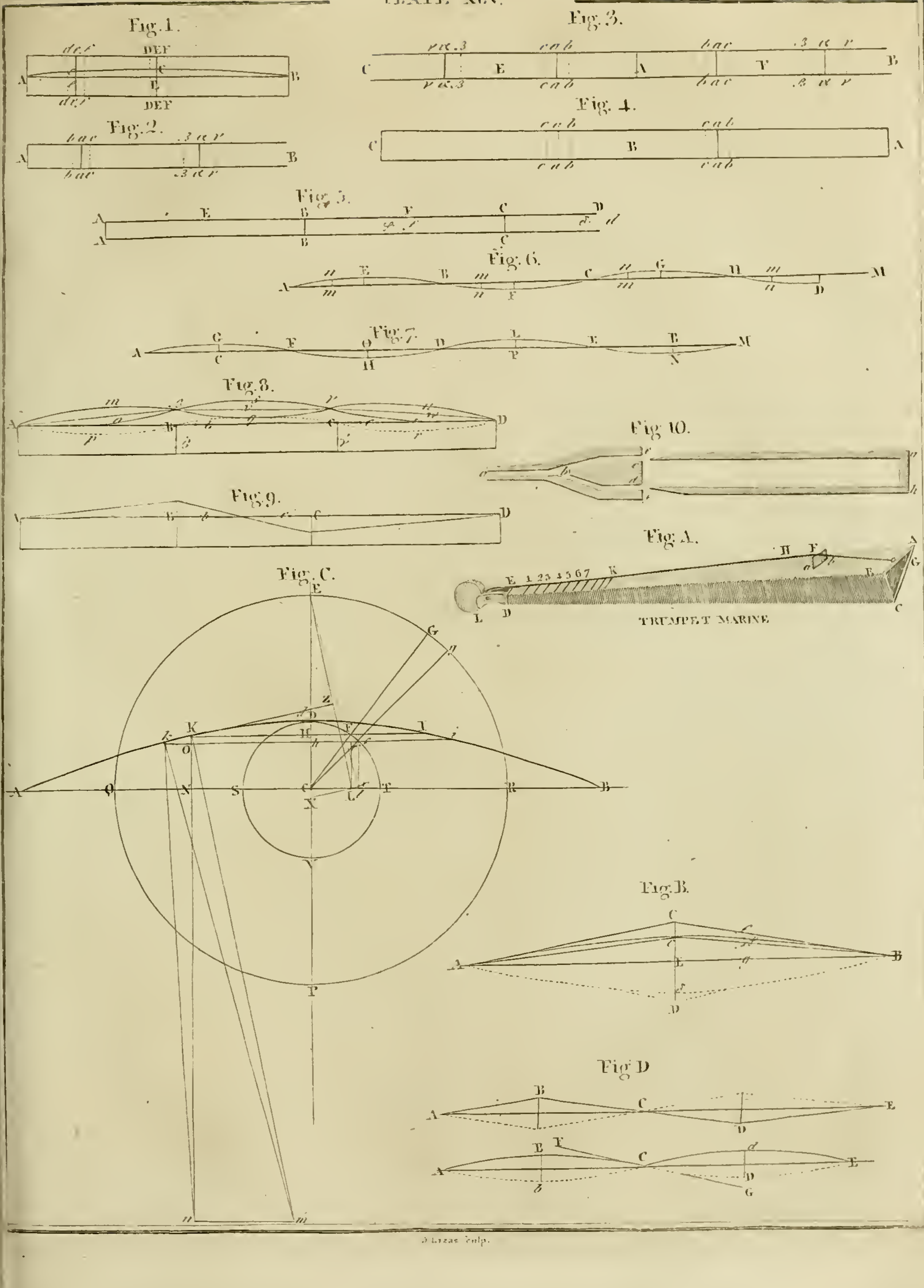
Musical Trumpet. Tschirnhaus.

TSCHIRNHAUS (Ehrenfred Walther Von), a name well known in the republic of letters, and one of the ornaments of the 17th century, was born April 10. 1651, at Kislingswald near Gorlitz in Upper Lusatia. His father was Ernest Christopher Von Tschirnhaus, Baron Kislingswald and Stoltzberg, and Obernschonfeld, privy counsellor, and in various offices of rank under the Electors George I. and II. of Saxony, the first of whom honoured him with the distinction of the gold chain and portrait, as a mark of his sense of his merits and services. The mother of the young Von Tschirnhaus was Maria Stirling, daughter of *Baro a Stirling et Achil*, Stirling of Achil, or Achyle, in Scotland, an old and respectable family, as appears by an epitaph which the Duke Christian, brother of the Elector George II. inscribed on the tomb of Johan Albert Stirling of Achil, in the cathedral of Marckspurg. This gentleman had been president of the senate of the electorate, privy counsellor, director of the imposts, and master of horse to the Prince, and had, by his faithful and useful services, acquired his highest esteem.

E. W. Von Tschirnhaus was born, as has been observed, at Kislingswald, the usual residence of the family, and possessed by it during more than 300 years. The family came originally from Bohemia, and appears to have been considerable, seeing that, from the earliest accounts of it in Lusatia, the Barons of Kislingswald are generally found in the most respectable civil offices.

The figure which Baron Von Tschirnhaus, the subject of this relation, has made in the scientific and political world, makes it superfluous to say that his early years

PLATE XLV.



J. Lizars Sculp.

years were well employed. Quick apprehenfion, a clear perception of the fubject of his thoughts, and the moft ardent and infatiable thirft for knowledge, diftinguifhed him during his academical education. When 17 years of age, he was fent to Leyden. In 1672 all ftudy was interrupted in Holland by the din of war; and Mr Von Tfchirnhaus left the univerfity for the camp. His knowledge in mathematics, mechanics, and all phyfical fcience, found ample room in the military fervice for fhewing the importance of thofe fciences; and Tfchirnhaus fo diftinguifhed himfelf by his fervice in this way, that Baron Nieuland, a general officer of great merit, and at the fame time an accomplifhed fcholar, took delight in pufhing him into every fervice where he could fhew himfelf and his talents.

After two years fervice, he returned to his father's; but finding little to intereft him in the life of a mere country gentleman, and ftill burning with the fame thirft of knowledge, he prevailed on his father to allow him to travel. His younger brother George Albrecht Von Tfchirnhaus, Baron Obernfchonfeld, which he inherited from his grandfather Stirling, loved him with the warmeft affection, and fupplied him liberally with what was required for his appearance everywhere in a manner becoming his rank, and for fully gratifying his curiofity. He ufed often to fay, "Sorry was I to lofe the company of my dear brother, and I fometimes wifhed to accompany him; but not having his thirft for knowledge, I knew that his love for me would debar him of much happinefs, which I fhould thus have obftructed." *Felices animæ!* He went to Holland, from thence into England, France, Italy, Sicily, Malta, Greece.—Returning through the Tyrol, he met his brother at Vienna, where both were in great favour at the court of Leopold. Wherever he went, he made himfelf acquainted with the moft eminent in all departments of fcience, living with them all in the mutual exchange of difcoveries and of kind offices. In Holland he was intimate with Huyghens and Hudde; in England, with Newton, Wallis, Halley, and Oldenburgh; in France, among a people who more fpeedily contract acquaintance, there was not a man of note with whom he did not cultivate an active acquaintance—and, fortunately, Leibnitz then lived at Paris: in Italy, he was particular careffed by Michaeli, foon after Cardinal; and was in the clofeft correfpondence with Kircher. His enjoyments, however, were derived folely from the communications of the moft eminent; his curiofity was directed to every thing, and wherever he faw an ingenious artifan, he was eager to learn from him fomething ufeful. In 1682, when at Paris for the third time, he communicated to his friends his celebrated theory of the cauftic curves, which marked him out as a valuable acquifition, and he was elected a member of the Royal Academy of Sciences, which was then reformed by the great minifter Colbert, and the moft illuftrious in all nations were picked out for its ornaments. There he found himfelf feated with Leibnitz, Huyghens, John Bernoulli, &c.

After twelve years employed in vifiting Europe, he returned home: but after a fhort ftay, went to Flanders, and prepared to publifh his work, intitled *Medicina Mentis*; of which the fubject may almoft be gueffed, from the way in which he had exercifed his own mind. Having the moft exalted notions of the intellectual and moral nature of man, he thought that the continual fupply of information was as neceffary as the continual fupply of food. And his great principle was TO ENLIGHTEN. This work was committed to the care of fome friends, and did not appear till 1687, at Amfterdam. A fecond edition appeared at Leipfic in 1695.

Finding now that his moderate fortune was infufficient for the great public projects he had in view, he fought for affiftance, and endeavoured to make friends by frequenting the court of the Elector at Drefden. He foon became a favourite of his Princes, George the II. and III. and was appointed to active offices of great refponfibility. By the orders and encouragement of the Elector, then king of Poland, he introduced into his native country the firft manufacture of glafs; and his project foon throve to fuch a degree, that not only Saxony was fupplied, but they even began to export the finer kinds of white glafs for windows; in which manufacture Saxony ftill excels. It was in the courfe of experiments for improving this manufacture that Tfchirnhaus made the celebrated great burning glaffes which ftill bear his name. He made two of thefe lenfes, and gave one to the Emperor, and the other to the Academy of Paris. He was eager to improve the art of forming and polifhing optical glaffes; and in the profecution of the theory on which their performance depends, he made fome beautiful difcoveries in the department of pure geometry. It is well known that all the fciences are allied, and of a family, and that eminence in one is feldom attainable without the affiftance of others. His prefent purfuits led him to the ftudy of chemiftry, which he profecuted with the fame ardour which he exhibited in every thing he undertook. But all the while, mathematics, and efpecially geometry, was his favourite ftudy; and he was anxious to make the fame advances in the general paths of mathematical inveftigation which he thought he had made in the general laws of material nature. He apprehended that only bye paths were yet known, and that many things were yet inacceffible; becaufe we had not yet found out the great roads from which thofe branches were derived. He was of Des Cartes's opinion, that the true road in mathematics muft be an eafy one, except in cafes which were, in their own nature, complicated. Very early, therefore, he began writing on mathematical fubjects, always continuing his general views of the fcience, and his endeavours to fyftematife the ftudy; but, at the fame time, beftowing a very particular attention on any branch which chanced to intereft him; each of thefe his epifodical ftudies in mathematics deferves the name of a department of the fcience. This is the cafe with his theory of cauftic curves, with his method of tangents, and his attempt to free Leibnitz's calculus from all confideration of infinitefimal quantities. Mr Tfchirnhaus feldom gave himfelf any trouble with a particular problem. In all his mathematical performances, there is an evident connection with fomething which he confidered as the great whole of the fcience; and the manner of treating the different queftions is plainly accommodated to a fyftem in his thoughts. This he intended as the third part of the Medicina Mentis; and, having nearly completed the fecond, he had propofed thefe as the occupation of the enfuing winter (1708-9). But his death, which may be called premature, has

Tfchirnhaus. has deprived the world of thefe, and other beneficent and ufeful labours.

Mr Von Tfchirnhaus was of the moft mild and gentle difpofition, as was well known to all who enjoyed his acquaintance. This difpofition was fo eminent in him, that fcarcely any perfon ever faw him angry, or even much ruffled in his temper. He forgave injuries frankly and heartily, and often ftood the friend (unknown) of thofe who had wronged him. By fuch conduct, he changed fome enmities into the moft fteady and affectionate friendfhips. As an inquirer and an inventor, he had contentions with other claimants, and fome difputes about the legitimacy of his methods; as, for example, with Nicholas Fatio Duiller, who attacked Tfchirnhaus's method of tangents; and Preftet and Rolle, who found fault with his expreffion of equations of the third degree. But thefe were all friendly debates, and never carried him beyond the limits of gentlemanly behaviour. He began to difpute with Ozanam about a quadratrix; but on being merely told that he was miftaken, by P. Souciet, he immediately acknowledged his error, and corrected it.

Many original and important mathematical performances of Mr Von Tfchirnhaus are to be feen in the Leipfic Acts, in the Memoirs of the Academy of Sciences at Paris, and other literary journals. His happy generalifation of Dr Barrow's theorem for the focus of a flender pencil of rays after reflection or refraction, and the theory of cauftic curves, in which this terminates, both conftitutes one of the moft elegant branches of optical fcience, and affords a rich harveft of very curious and unexpected geometrical truths. The manner in which he notices the rough way in which his firft and fole miftake in this theory was pointed out, is perhaps incomparable as an example of gentlemanlike reprehenfion, and is a leffon for literati of all defcriptions, higly valuable on account of the foft way in which it falls, while it is convincing as a mathematical theorem.

Tfchirnhaus was the difcoverer of the fubftance of which the celebrated Saxon porcelain is made, and of the manner of working it up; by which he eftablifhed a manufacture highly profitable to his country, and has given us the fineft pottery in the world. He never wearied in fpreading ufeful knowledge; and the fhops of our artifans of almoft all kinds were fupplied with books of inftructions and patterns, many of them written by Mr Von Tfchirnhaus, or under his infpection. Ufeful books of all kinds were tranflated out of foreign languages at his expence. Men of genius in the arts were enabled, through the encouragement of himfelf and his friends, and often by his pecuniary affiftance, to bring their talents before the public eye. In fhort, he feemed at all times to prefer the public good to his own; and never felt fo much pleafure as when he could promote fcience or the ufeful arts. He was as it were ftimulated to this by an innate propenfity. And as he was more defirous of *being* than of *appearing* the accomplifhed man, he was in no concern what notice others took of his fervices to the public. He even reprefents the defire of fame as hoftile to the improvement either of fcience or morality, in his *Medicina Mentis*; a work which is acknowledged by all who knew him to be a picture of his own amiable mind. He lightly efteemed riches; and knew not what ufe they were of, except for providing the neceffaries of life, and the means of acquiring knowledge. In perfect conformity to this maxim, he modeftly, and with elegant refpect, refufed the ample prefents made him by his affectionate fovereign; and when he was added to his cabinet council, he received the diploma, but begged and obtained to be free from the title. And when he prefented his great burning glafs to the Emperor, and got from him the dignity and infignia of Baron of the Empire, he pleaded for leave to decline it, requefting to keep the chain and portrait, which he always wore under his veft. He expended a very great portion of the ample revenue left him by his father in the fervice of his country, by promoting the ufeful arts and fciences.

Mr Von Tfchirnhaus venerated truth above all things; faying, that thofe who thought any thing comparable with it were not the fons of God, but ftep-children, and that the love of truth is the ruling affection in every man of a worthy heart. In a letter to an intimate friend, he faid that, by the age of five and-twenty, he had completely fubdued the love of glory, of riches, and of worldly pleafures; and that at no time he had found it difficult to reprefs vanity, becaufe he was every day confcious of having acted worfe than he was certain that he might and fhould have done. He felt himfelf humbled in the fight of the All-perfect Judge.

Nor was all this the vain boaft of a man averfe to bufinefs, and poffeffed of an ample fortune, which permitted him, without inconvenience, to pleafe his fancy in ftudy, and in helping others with what to himfelf was fuperfluous. Such a character, though rare, may exift, without being the object of much refpect. No: Mr Tfchirnhaus was really a philofopher of the true ftoic fect, in refpect of fortitude of mind, while a good Chriftian in modefty and diffidence. In the laft five years of his life he bore up under troubles, and embarraffments, and misfortunes in his family, which would have tried the mind of Cato himfelf. But in the midft of thefe ftorms he was unfhaken, and preferved his ferenity of mind. He was even fenfible of this being a rare gift of Providence, and ufed frequently to exprefs his thankfulnefs for a treafure fo precious. He felt deeply his relation to the Author of Nature, and rejoiced in thinking himfelf fubject to the providence of God. He faid that he was fully perfuaded that he would meet with perfect juftice, and would therefore ftrive to perform his own part to the utmoft of his power, that his future condition might be the more happy, and that he might in the mean time enjoy more fatisfaction on reflecting on his own conduct. His lot, he faid, was peculiarly fortunate: having fuch thirft for novelty, he would have been unhappy without an affluent fortune; and his own enjoyments encouraged neither vice nor idlenefs in himfelf or in the minifters to his pleafures.

This amiable perfon was of a conftitution not puny, but not robuft, and he had hurt it by too conftant ftudy. He feared no difeafe; thinking that he had a cure or an alleviation for all but one, namely, the ftone and gravel. He had a dread of this, and laboured to find a preventative or a remedy. He thought that he had alfo done a great deal here; and defcribes in his *Medicina Corpores* a preparation of whey, which he faid he ufed with great advantage to his health. But his precautions were in vain: He was attacked with the gravel, which, after three months fuffering, brought on a fuppreffion of urine. The phyficians faw that his end approached; and finding him difregard their prefcriptions, they quitted him. He treated himfelf (it is faid judicioufly) for fome time, and with fome appearance of fuccefs; but at laft he faw death not far off. He dictated a letter to his Sovereign, thanking him for all his favours and kindnefs, and recommended his children to his protection. He never fretted nor complained; but frequently, with gliftening eyes, expreffed his warmeft thanks to Providence for the wonderful track of good fortune and of happinefs that he had enjoyed; and faid that he alfo felt fome fatisfaction in the confcioufnefs that fome of this was owing to his own prudent conduct. He poffeffed his entire faculties to the laft moment; and when he felt his fpirit juft about to depart, his laft words were, "*Jö triumphè—Victoria!*" No longer able to fpeak, he made figns for what he wanted; and a little after, fhutting his eyes, as if to fleep, he gently, and without a groan, yielded up his fpirit, about four o'clock in the morning of the 11th of October 1708, aged 56.

His funeral was performed in a manner becoming his rank, and the body conveyed to the family vault. The Elector (King of Poland) defrayed the expence; for he would not allow his family to have any thing to do with the funeral of a man of fo public a character, and fo univerfally beloved.

The account of fuch a life as that of Baron Von Tfchirnhaus would, at all times, make a pleafant and ufeful impreffion. In thefe our times, in the end of the 18th century, after fociety has availed itfelf of all the acquifitions in fcience and art, furnifhed by that ardent age of the world which this gentleman contributed to adorn; in an age when we boaft of illumination unparalleled in hiftory, and of improvements almoft amounting to perfection; and in particular, of an emancipation from the prejudices which had obfcured our view of the chief good, and ftifled public fpirit—now, when we are fo full of knowledge that it is running over on all hands, in volumes of inftruction, how to make the world one happy family; in thefe bright days of philanthropifm, can the public records of Europe exhibit a fuperior character to that of Mr Von Tfchirnhaus, either in refpect of wifdom or of difpofition? Was he not a philanthropift, a fincere lover of mankind? Was he not wife, in employing his great acquired knowledge as the means of direct and active beneficence, by limiting his exertions to the extent of thofe circles where his own efforts would be effective? He did not write books, teaching others how to do good: he taught it by example; being determined that his own wifhes to fee men happier fhould not fail by the want of fuch wifhes in others, even after he fhould inftruct them. He never allowed his infatiable curiofity for frefh difcoveries to interfere with the immediate turning to the good of his own country the knowledge he had already acquired. He probably never thought of improving the fituation of the Chinefe or the Mexicans, finding that it required all his ample fortune, and all the intereft and influence he could acquire, to do the good he wifhed in Saxony. We doubt not but that he was equally attentive to the ftill narrower circle of duties formed by his own family. We fee that he was a dearly beloved brother; which could hardly be without his alfo being a loving brother and a dutiful fon. The nature of the diftreffes which he experienced in his family, and the manner in which he behaved under them, fhew him to have been an eminent Chriftian moralift. With a modefty that is unmatched by any one of the thoufands who have poured out inftructions upon us during the laft ten years, and a gracefulnefs which characterifes the gentleman, his *Medicina Mentis* is offered to public notice, merely as an experimental proof that a certain way of thinking and acting is productive of internal quiet of mind; of great mental enjoyment, both moral and intellectual; and of peace, and the good will of thofe around us: and that it did, in fact, produce a dutiful and comfortable refignation to the unavoidable trials of human life. He pretends not to be greatly fuperior in wifdom to his neighbours, but merely tells how things fucceeded with himfelf. He did not fcruple, however, to publifh to the world difcoveries in fcience, in which he had got the ftart of others during that bufy period of fcientific occupation: and thefe difcoveries in mathematics were highly prized by the firft men of the age; nor will the name of Tfchirnhaus, or his cauftic curves, ever be forgotten.

We felt ourfelves obliged to the friend who took notice of the omiffion of this gentleman's name, fo eminent in the mathematical world, in the courfe of our alphabet; but when we looked into the Memoirs of the Academy of Paris for 1709 for fome account of him, what we there faw appeared fuch a continual panegyric, that we could not take it as a fair picture of any real character. Looking about for more impartial information, we found in the *Acta Eruditorum*, Leipf. 1709, the account of which the foregoing is an abftract, except a particular or two which we have copied from an account in the Literary Journal of Breflaw, by Count Herberftein, whom we can fcarcely fufpect of undue partiality, becaufe he had fome difputes with Mr Von Tfchirnhaus on mathematical fubjects. May we not fay, "the memory of this man is fweet!"

TSCHAMIE, the Indian name of a tree in the Northern Circars of Hindoftan. It grows, fays Dr Roxburgh, to be a pretty large tree, is a native of moft parts of the coaft, chiefly of low lands at a confiderable diftance from the fea, and may be only a variety of *profopis fpecigera*, for the thorns are in this fometimes wanting; flowers during the cold and beginning of the hot feafons. *Trunk* tolerably erect, bark deeply cracked, dirty afh colour. *Branches* irregular, very numerous, forming a pretty large fhady head. *Prickles* fcattered over the fmall branches; in fome trees wanting. *Leaves* alternate, generally bipinnate, from two to three inches long; pinnæ from one to four, when in pairs oppofite, and have a gland between their infertions. *Leaflets* oppofite, from feven to ten pair, obliquely lanced, fmooth, entire, about half an inch long, and one-fixth broad. *Stipules* none. *Spikes* feveral, axillary, filiform, nearly erect. *Bracts* minute, one-flowered, falling. *Flowers* numerous, fmall, yellow, fingle, approximated. *Calyx* below, five-toothed. *Filaments* united at the bafe. *Anthers* incumbent, a white gland on the apex of each, which falls off foon after the flower expands. *Style* crooked.

Tſhutſki, Tucker.

crooked. *Stigma* ſimple. *Legume* long, pendulous, not inflated. *Seeds* many, lodged in a brown meally ſubſtance.

The pod of this tree is the only part uſed. It is about an inch in circumference, and from ſix to twelve long; when ripe, brown, ſmooth, and contains, beſides the feeds, a large quantity of a brown meally ſubſtance, which the natives eat; its taſte is ſweetiſh and agreeable; it may therefore be compared to the Spaniſh *algaroba*, or locuſt tree. (*Ceratcnia ſiliqua*, Linn.)

In compliance with Dr Kœnig's opinion, Dr Roxburgh calls this tree a *proſopis*; but as he thinks the antheral glands give it a claim to the genus *adenanthera*, we have retained the Indian name till its botanical claſſification ſhall be aſcertained by thoſe who have greater authority in the ſcience than we lay claim to.

TSHUTSKI, a people inhabiting a country ſituated on the eaſtern extremity of Aſia, oppoſite to the north weſt coaſt of America, and bounded by the Anadyr on the ſouth. The Tſhutſki nation is divided into two very diſtinct tribes: the one is called *ſtationary*, or fixed inhabitants of the coaſt; the other, *Reindeer*, or wanderers. The former occupy ſuch places as are convenient for fiſhing, and the chace of ſea-animals, from the river Anadyr to a ſmall diſtance north of the eaſtern promontory. The extent of their population, according to the beſt intelligence, amounts to about 3000 males. They are very induſtrious, and are neat workmen; which is evinced by their boats, lances, arrows, bows, apparel, utenſils, &c. with which they ſupply the wanderers. Their female priſoners are alſo a great article of trade; as they barter them for reindeer, copper and iron kettles, knives, beads, and ſuch articles as the wanderers obtain from the Ruſſian traders. Their married women are faithful to their huſbands; but chaſtity ſeems not to be a virtue among the unmarried part of the ſex, who grant any favours to ſtrangers for beads, buttons, tobacco, &c.

The aged among the Tſhutſki are ſubject to rheumatic complaints, which they cure, or attempt to cure, by lighting the dried leaves of wormwood, ſo prepared as to burn like tinder, and letting it remain till burnt out on the parts affected. In caſes of ſevere illneſs, they offer ſacrifices of deer to *the ſpirits of torture*; and ſometimes a dog is killed, when the ſick are led round it, and anointed with its blood and fat. They burn their dead to aſhes; lay ſtones on the ſpot to reſemble, in ſome degree, the form of a man; place a large ſtone at the head, which they anoint with marrow and fat; and form a pile, or heap of deers horns, at a ſmall diſtance from it. This place is viſited annually by the relatives of the deceaſed, who recapitulate the feats of their departed friend, anointing, each, the head-ſtone, and adding a horn to the heap. The wandering tribe conſider themſelves as a ſuperior race of beings, and the moſt independent of men; and it is a fact that the Ruſſians have never been able to bring them under their dominion. They call their more ſtationary neighbours *old women*, fit only to attend on them, and to guard their cattle. By Brookes the country of the Tſhutſki is placed Long. 168. 41. W. Lat. 66. 5. N.

TUCKER (Abraham), Eſq; a curious and original thinker, was a gentleman of affluent fortune, and author of "The Light of Nature purſued," 9 vols 8vo; of which the five firſt volumes were publiſhed by himſelf in 1768, under the aſſumed name of "Edward Search, Eſq." and the four laſt after his death, in 1777, as "The poſthumous Work of Abraham Tucker, Eſq. publiſhed from his manuſcript as intended for the preſs by the author." Mr Tucker lived at Betchworth-caſtle, near Dorking in Surrey; an eſtate which he purchaſed in the early part of his life. He married the daughter of Edward Barker, Eſq. by whom he had two daughters; one of whom married Sir Henry St John, and died in his lifetime; the other ſurvived, and now lives at Betchworth-caſtle. He loſt his eyeſight a few years before his death, which happened in 1775. To deſcribe him as a neighbour, landlord, father, and magiſtrate, it would be neceſſary to mention the moſt amiable qualities in each. It is unneceſſary to add, that he was very ſincerely regretted by all who had the pleaſure of his acquaintance, and who ſtood connected with him in any of thoſe relations.

Tucker.

TUCKER (Joſiah, D. D.), well known as a political and commercial writer, was born at Langhorn in Caermarthenſhire, in the year 1712. His father was a farmer, and having a ſmall eſtate left him at or near Aberyſtwith, in Cardiganſhire, he removed thither; and perceiving that his ſon had a turn for learning, he ſent him to Ruthin ſchool in Denbighſhire, where he made ſo reſpectable a progreſs in the claſſics, that he obtained an exhibition at Jeſus College, Oxford. It is generally underſtood that ſeveral of his journeys to and from Oxford were performed on foot, with a ſtick on his ſhoulder, and bundle at the end of it. Thus it might be ſaid by him, as by Simonides, "*Omnia mea mecum porto.*"

At the age of 23 he entered into holy orders, and ſerved a curacy for ſome time in Glouceſterſhire. About 1737 he became curate of St Stephen's church in Briſtol, and was appointed minor-canon in the cathedral of that city. Here he attracted the notice of Dr Joſeph Butler, then Biſhop of Briſtol, and afterwards of Durham, who appointed Mr Tucker his domeſtic chaplain. By the intereſt of this prelate Mr Tucker obtained a probendal ſtall in the cathedral of Briſtol; and on the death of Mr Catcott, well known by his treatiſe on the Deluge, and a volume of excellent ſermons, he became rector of St Stephen. The inhabitants of that pariſh conſiſt chiefly of merchants and tradeſmen; a circumſtance which greatly aided his natural inclination for commercial and political ſtudies.

When the famous bill was brought into the Houſe of Commons for the naturalization of the Jews, Mr Tucker, conſidering the meaſure rather as a merchant or politician than as a Chriſtian divine, wrote in defence of it with a degree of zeal which, to ſay no more, was at leaſt indecent in a man of his profeſſion. As ſuch it was viewed by his brethren of the clergy, and by his pariſhioners; for, while the former attacked him in pamphlets, newſpapers, and magazines, the latter burnt his effigy dreſſed in canonicals, together with the letters which he had written in defence of the naturalization.

In the year 1753 he publiſhed an able pamphlet on the "Turkey Trade;" in which he demonſtrates the evils that reſult to trade in general from chartered companies. At this period Lord Clare (afterward Earl Nugent) was returned to Parliament for Briſtol; which honour

honour he obtained chiefly through the ftrenuous exertions of Mr Tucker, whofe influence in his large and wealthy parifh was almoft decifive on fuch an occafion. In return for this favour, the Earl procured for him the deanery of Gloucefter, in 1758, at which time he took his degree of doctor in divinity. So great was his reputation for commercial knowledge, that Dr Thomas Hayter, afterwards bifhop of London, who was then tutor to his prefent majefty, applied to Dr Tucker to draw up a differtation on this fubject for the perufal of his royal pupil. It was accordingly done, and gave great fatisfaction. This work, under the title of "The Elements of Commerce," was printed in quarto, but never publifhed.

Dr Warburton, who became bifhop of Gloucefter in the year 1760, thinking very differently from Dr Tucker of the proper ftudies of a clergyman, as well as of the project for naturalizing the Jews, faid once to a perfon who was praifing the Elements of Commerce, that "his Dean's trade was religion, and religion his trade." This farcafm, though not perhaps groundlefs, was certainly too fevere; for fome of the Dean's publications evince him to have devoted part of his time at leaft to the ftudy of theology, and to have been a man of genuine benevolence.

In the year 1771, when a ftrong attempt was made to procure an abolition of fubfcription to the 39 articles, Dr Tucker came forward as an able and moderate advocate of the church of England. About this time he publifhed "Directions for Travellers;" in which he lays down excellent rules, by which gentlemen who vifit foreign countries may not only improve their own minds, but turn their obfervations to the benefit of their native country.

The Dean was an attentive obferver of the American conteft. He examined the affair with a very different eye from that of a party-man, or an interefted merchant; and he difcovered, as he conceived, that both fides would be better off by an abfolute feparation. Mr Burke's language in the Houfe of Commons, in confequence of his publifhing this opinion, was harfh, if not illiberal. In his famous fpeech on the American taxation bill, April the 13th, 1774, he called the Dean of Gloucefter the advocate of the court faction, though it is well known that the court difapproved of the propofal as much as the oppofition. This attack roufed the Dean to refentment; and he publifhed a letter to Mr Burke; in which he not only vindicates the purity of his own principles, but retorts upon his adverfary in very forcible and farcaftic terms. He afterwards fupported Lord Nugent's intereft in Briftol againft that of Mr Burke, and was certainly very inftrumental in making the latter lofe his election.

When the terrors of an invafion were very prevalent in 1779, Dr Tucker circulated, in a variety of periodical publications, fome of the moft fenfible obfervations that were ever made on the fubject, in order to quiet the fears of the people. In 1781 he publifhed, what he had printed long before, "A Treatife on Civil Government;" in which his principal defign is to counteract the doctrines of Locke and his followers. The book made a confiderable noife, and was very fharply attacked by feveral writers on the democratic fide of the queftion, particularly by Dr Towers and Dr Dunbar of Aberdeen. This laft gentleman acted a part which, if not difhonourable, was at leaft uncommon. The Dean had thrown off thirty copies of his work long before he publifhed it; and thefe he fent to different men of eminence, that he might avail himfelf of their animadverfions before he fhould fubmit it to the public at large. Principal Campbell of Aberdeen received one copy for this purpofe; and Dr Dunbar having by him bee[n] favoured with a perufal of it, inftead of fending his o[b]jections privately to the author, publifhed fevere re[mar]ks on it in a work which he had then in the prefs. [Th]is was the anfwer to the Dean of Gloucefter's Tr[eati]fe on Government publifhed before that treatife itfel[f] but Dr Dunbar was no match for Dr Tucker.

In the year 1782 our author clofed his political career with a pamphlet intitled "*Cui Bono?*" in which he balances the profit and lofs of each of the belligerent powers, and recapitulates all his former pofitions on the fubject of war and colonial poffeffions. His publications fince that period confifted of fome tracts on the commercial regulations of Ireland, on the exportation of woollens, and on the iron trade. In 1777 he publifhed feventeen practical fermons, in one volume octavo. In the year 1778, one of his parifhioners, Mifs Pelloquin, a maiden lady of large fortune and moft exemplary piety, bequeathed to the Dean her dwelling houfe in Queen Square, Briftol, with a very handfome legacy, as a teftimony of her great efteem for his worth and talents. In the year 1781 the Dean married a lady of the name of Crowe, who refided at Gloucefter.

It fhould be recorded to his praife, that though enjoying but very moderate preferment (for to a man of no paternal eftate, or other ecclefiaftical dignity, the Deanery of Gloucefter is no very advantageous fituation), he was notwithftanding a liberal benefactor to feveral public inftitutions, and a diftinguifhed patron of merit. The celebrated John Henderfon of Pembroke-college, Oxford, was fent to the univerfity, and fupported there, at the Dean's expence, when he had no means whatever of gratifying his ardent defire for ftudy. We fhall mention another inftance of generofity in this place, which reflects the greateft honour upon the Dean. About the year 1790 he thought of refigning his rectory in Briftol, and without communicating his defign to any other perfon, he applied to the Chancellor, in whofe gift it is, for leave to quit it in favour of his curate, a moft deferving man, with a large family. His Lordfhip was willing enough that he fhould give up the living, but he refufed him the liberty of nominating his fucceffor. On this the Dean refolved to hold the living himfelf till he could find a fit opportunity to fucceed in his object. After weighing the matter more deliberately, he communicated his wifh to his parifhioners, and advifed them to draw up a petition to the Chancellor in favour of the curate. This was accordingly done, and figned by all of them, without any exception, either on the part of the diffenters or others. The Chancellor being touched with this teftimony of love between a clergyman and his people, yielded at laft to the application; in confequence of which the Dean cheerfully refigned the living to a fucceffor well qualified to tread in his fteps. Since that time he refided chiefly at Gloucefter, viewing his approaching diffolution with the placid mind of a Chriftian, confcious of having done his duty both to God and man. He died in November 1799.

Tucker, Tulipomania.

1799. The following we believe to be a tolerably correct lift of his works.

Theological and Controverfial.—1. A Sermon, preached before the Governors of the Infirmary of Briftol, 1745. 2. Letters in behalf of the Naturalization of the Jews. 3. Apology for the Church of England, 1772. 4. Six Sermons, 12mo, 1773. 5. Letter to Dr Kippis on his Vindication of the Proteftant Diffenting minifters. 6. Two Sermons and Four Tracts. 7. View of the Difficulties of the Trinitarian, Arian, and Socinian Syftems, and Seventeen Sermons, 1777.

Political and Commercial.—8. A pamphlet on the Turkey Trade. 9. A brief View of the Advantages and Difadvantages which attend a Trade with France. 10. Reflections on the Expediency of Naturalizing foreign Proteftants, and a Letter to a Friend on the fame Subject. 11. The Pleas and Arguments of the Mother Country and the Colonies ftated. 12. A Letter to Mr Burke. 13. Quere, Whether a Connection with, or Separation from, America, would be for national Advantage? 14. Anfwers to Objections againft the Separation from America. 15. A Treatife on Civil Government. 16. *Cui Bono?* 17. Four Letters on national Subjects. 18. Sequel to Sir William Jones on Government. 19. On the Difpute between Great Britain and Ireland. 20. Several Papers under the Signature of Caffandra, &c. on the Difficulties attendant on an Invafion. 21. A Treatife on Commerce (Mr Coxe, in his Life of Sir Robert Walpole, fays that this was printed, but never publifhed).

Mifcellaneous.—22. Directions for Travellers. 23. Cautions againft the Ufe of Spirituous Liquors. 24. A Tract againft the Diverfions of Cock-fighting, &c.

TULIPOMANIA, the very proper name given to a kind of gambling traffic in *tulip roots*, which prevailed in Holland and the Netherlands during fome part of the 17th century. It was carried on to the greateft extent in Amfterdam, Haerlem, Utrecht, Alkmaar, Leyden, Rotterdam, Hoorn, Enkhuyfen, and Meedenbliek; and rofe to the greateft height in the years 1634, 1635, 1636, and 1637. Munting, who, in 1696, wrote a book of 1000 pages folio on the fubject, has given a few of the moft extravagant prices, of which we fhall prefent the reader with the following. For a root of that fpecies called the *Viceroy*, the after mentioned articles, valued as below, were agreed to be delivered.

	Florins.
2 lafts of wheat	448
4 ditto rye	558
4 fat oxen	480
8 fat fwine	240
12 fat fheep	120
2 hogfheads of wine	70
4 tons beer	32
2 ditto butter	192
1000 pounds of cheefe	120
a complete bed	100
a fuit of clothes	80
a filver beaker	60
Sum	2500

Thefe tulips afterwards were fold according to the weight of the roots. Four hundred perits * of Admiral Liefken coft 4400 florins; 446 ditto of Admiral Von der Eyk, 1620 florins; 106 perits Schilder coft 1615 florins; 200 ditto Semper Auguftus, 5500 florins; 410 ditto Viceroy, 3000 florins, &c. The fpecies Semper Auguftus has been often fold for 2000 florins; and it once happened that there were only two roots of it to be had, the one at Amfterdam and the other at Haerlem. For a root of this fpecies, one agreed to give 4600 florins, together with a new carriage, two grey horfes, and a complete harnefs. Another agreed to give twelve acres of land for a root: for thofe who had not ready money, promifed their moveable and immoveable goods, houfe and lands, cattle and clothes. A man, whofe name Munting once knew, but could not recollect, won by this trade more than 60,000 florins in the courfe of four months. It was followed not only by mercantile people, but alfo by the firft noblemen, citizens of every defcription, mechanics, feamen, farmers, turf-diggers, chimney-fweeps, footmen, maid-fervants, and old clothes-women, &c. At firft, every one won and no one loft. Some of the pooreft people gained in a few months houfes, coaches, and horfes, and figured away like the firft characters in the land. In every town fome tavern was felected which ferved as a change, where high and low traded in flowers, and confirmed their bargains with the moft fumptuous entertainments. They formed laws for themfelves, and had their notaries and clerks.

* A *perit* is a fmall weight lefs than a grain.

To get poffeffion of fine flowers was by no means the real object of this trade, though many have faid that it was, and though we have known fome individuals in Scotland, who, led away by what they thought the fafhion, have given ten guineas for a tulip root. During the time of the tulipomania, a fpeculator often offered and paid large fums for a root which he never received, and never wifhed to receive. Another fold roots which he never poffeffed or delivered. Oft did a nobleman purchafe of a chimney-fweep tulips to the amount of 2000 florins, and fold them at the fame time to a farmer; and neither the nobleman, chimney-fweep, or farmer, had roots in their poffeffion, or wifhed to poffefs them. Before the tulip feafon was over, more roots were fold and purchafed, befpoke, and promifed to be delivered, than in all probability were to be found in the gardens of Holland; and when Semper Auguftus was not to be had, which happened twice, no fpecies perhaps was oftener purchafed and fold. In the fpace of three years, as Munting tells us, more than ten millions were expended in this trade in only one town of Holland.

To underftand this gambling traffic, it may be neceffary to make the following fuppofition. A nobleman befpoke of a merchant a tulip root, to be delivered in fix months, at the price of 1000 florins. During thefe fix months the price of that fpecies of tulip muft have rifen or fallen, or remained as it was. We fhall fuppofe that, at the expiration of that time, the price was 1500 florins; in that cafe, the nobleman did not wifh to have the tulip, and the merchant paid him 500 florins, which the latter loft and the former won. If the price was fallen when the fix months were expired, fo that a root could be purchafed for 800 florins, the nobleman then paid to the merchant 200 florins, which he received as fo much gain; but if the price continued the fame, that is, 1000 florins, neither par-

Tulipomania. ty gained or loſt. In all theſe circumſtances, however, no one ever thought of delivering the roots or of receiving them. Henry Munting, in 1636, ſold to a merchant at Alkmaar, a tulip root for 7000 florins, to be delivered in ſix months; but as the price during that time had fallen, the merchant paid, according to agreement, only 10 *per cent.* "So that my father (ſays the ſon) received 700 florins for nothing; but he would much rather have delivered the root itſelf for 7000." The term of theſe contracts was often much ſhorter, and on that account the trade became briſker. In proportion as more gained by this traffic, more engaged in it; and thoſe who had money to pay to one, had ſoon money to receive of another; as at faro, one loſes upon one card, and at the ſame time wins on another. The tulip dealers often diſcounted ſums alſo, and transferred their debts to one another; ſo that large ſums were paid without caſh, without bills, and without goods, as by the Virements at Lyons. The whole of this trade was a game at hazard, as the Miſſiſſippi trade was afterwards, and as ſtock-jobbing is at preſent. The only difference between the tulip trade and ſtock-jobbing is, that at the end of the contract the price in the latter is determined by the Stock Exchange; whereas in the former it was determined by that at which moſt bargains were made. High and low priced kinds of tulips were procured, in order that both the rich and the poor might gamble with them; and the roots were weighed by perits, that an imagined whole might be divided, and that people might not only have whole, but half and quarter lots. Whoever is ſurpriſed that ſuch a traffic ſhould become general, needs only to reflect upon what is done where lotteries are eſtabliſhed, by which trades are often neglected, and even abandoned, becauſe a ſpeedier mode of getting fortunes is pointed out to the lower claſſes.

At length, however, this trade fell all of a ſudden. Among ſuch a number of contracts many were broken; many had engaged to pay more than they were able; the whole ſtock of the adventurers was conſumed by the extravagance of the winners; new adventurers no more engaged in it; and many becoming ſenſible of the odious traffic in which they had been concerned, returned to their former occupations. By theſe means, as the value of tulips ſtill fell, and never roſe, the ſellers wiſhed to deliver the roots *in natura* to the purchaſers at the prices agreed on; but as the latter had no deſire for tulips at even ſuch a low rate, they refuſed to take them or to pay for them. To end this diſpute, the tulip-dealers of Alkmaar ſent, in the year 1637, deputies to Amſterdam; and a reſolution was paſſed on the 24th of February, that all contracts made prior to the laſt of November 1636 ſhould be null and void; and that, in thoſe made after that date, purchaſers ſhould be free on paying ten *per cent.* to the vender.

The more diſguſted people became with this trade, the more did complaints increaſe to the magiſtrates of the different towns; but as the courts there would take no cognizance of it, the complainants applied to the States of Holland and Weſt Frieſland. Theſe referred the buſineſs to the determination of the provincial council at the Hague; which, on the 27th of April 1637, declared that it would not deliver its opinion on this traffic until it had received more information on the ſubject; that in the mean time every vender ſhould offer his tulips to the purchaſer; and, in caſe he refuſed to receive them, the vender ſhould either keep them, or ſell them to another, and have recourſe on the purchaſer for any loſs he might ſuſtain. It was ordered alſo, that all contracts ſhould remain in force till farther enquiry was made. But as no one could foreſee what judgment would be given reſpecting the validity of each contract, the buyers were more obſtinate in refuſing payment than before; and venders, thinking it much ſafer to accommodate matters amicably, were at length ſatisfied with a ſmall profit inſtead of exorbitant gain: and thus ended this extraordinary traffic, or rather gambling. *Beckmann's Hiſtory of Inventions*, vol. i.

Tulipomania || Turnsol.

TUMAR, in Bengal, rent-roll or aſſeſſment.

TUMBREL, is a kind of carriage with two wheels, uſed either in huſbandry for dung, or in artillery to carry the tools of the pioneers, &c. and ſometimes likewiſe the money of an army.

TUNGSTEN (See CHEMISTRY, n° 178, &c. in this *Suppl.*) when well fuſed, is, according to Guyton *alias* Morveau, of no higher ſpecific gravity than 8.3406. This is very different from the ſpecific gravity which has hitherto been aſſigned to it. The ſame eminent chemiſt concludes, from its extreme brittleneſs and difficulty of fuſion, that it affords little promiſe of utility in the arts, except in metallic alloys, or by virtue of the property which its oxyd poſſeſſes, of affording fixed colours, or giving fixity to the colours of vegetables.

TURNSOL, a dye-ſtuff manufactured in Holland, the preparation of which was long kept a profound ſecret. In order to miſlead foreigners, the Dutch pretended that turnſol was made from rags dyed with the juice of the ſun-flower (*Helianthus*), from which it obtained its name. Since the late revolution, however, in Holland, the true method employed by the Dutch for preparing this colour has been diſcovered, and the proceſs is as follows:—That kind of lichen called orchil (*Lichen-Rocella.* See that article in this *Suppl.*), or, when that cannot be procured, the large oak moſs, after being dried and cleaned, is reduced to powder, and by means of a kind of oil-preſs the powder is forced thro' a braſs ſieve, the holes of which are ſmall. The ſifted powder is then thrown into a trough and mixed with an alkali called *vetas*, which is nothing elſe than the aſhes of wine lees, in the proportion of half a pound of aſhes to one pound of powder. This mixture is moiſtened with a little human urine, for that of other animals contains leſs ammonia, by which a fermentation is produced; and the moiſtneſs is ſtill kept up by the addition of more urine. As ſoon as the mixture aſſumes a red colour, it is poured into another trough; is again moiſtened with urine, and than ſtirred round in order that the fermentation may be renewed. In the courſe of a few days it acquires a bluiſh colour, and is then carefully mixed with a third part of very pure pulveriſed potaſh; after which the mixture is put into wooden pails, three feet in height, and about half a foot broad. When the third fermentation takes place, and the paſte has acquired a conſiderably dark blue colour, it is mixed with chalk or pulveriſed marble, and ſtirred well round that the whole may be completely united. This laſt ſubſtance gives the colour no higher quality, and is intended merely to add to the weight. The blue, prepared in this manner, is poured into oblong ſquare iron moulds;

moulds; and the cakes, when formed, are placed upon fir boards on an airy floor in order to dry, after which they are packed up for sale.

TURPENTINE, a well known fubftance extracted from the pine. Under the article PINUS (*Encycl.*), we have given an account of one procefs by which this extract is made; but the following, which is taken from the 31ft volume of the *Journal de Phyfique*, is very different, and probably better. The pine from which turpentine is extracted, is never fit for this operation till it be thirty years of age. The extraction is begun in February and continued to the end of October. Incifions are made with an hatchet, beginning at the foot of the tree on one fide, and rifing fucceffively: they are repeated once or twice a week, the fize about one finger's breadth acrofs, and three or four inches long. During the four years in which it is continued, the incifions have rifen to about eight or nine feet. Then the incifions are begun on the other fide; and during this time the old ones fill up, and may be again opened after fome years; fo that a tree on a good foil, and well managed, may yield turpentine for a century. At the bottom of the tree, under the incifion, a hole is dug in the ground to receive the refin which flows from the tree. This refin is called *terebinthine brut*, is of a milky colour, and is that which flows during the three fummer months; it requires further purification.

The winter crop is called *barras galipot*, or white refin: it fticks to the bark of the tree, when the heat has not been ftrong enough to let it flow into the trough in the ground. It is fcraped off with iron knives.

Two methods are practifed for purifying thefe refins. That which is followed at Bayonne is to have a copper cauldron which will hold 300lb. of materials fixed over a fire, and the flame circulating at the bottom of the copper. The turpentine is put in, melted with a gentle heat, and, when liquid, it is ftrained through a ftraw-bafket made for the purpofe, and ftretched over a barrel, which receives the ftrained turpentine. This purification gives it a golden colour, and may be performed at all times of the year.

The fecond manner, which is practifed only in the mountain of De Buch, near Bourdeaux, confifts in having a large tub, feven or eight feet fquare, and pierced with fmall holes at the bottom, fet upon another tub to catch the liquor. This is expofed to the hotteft fun for the whole day, filled two thirds with turpentine, which as it melts falls through the holes, and leaves the impurities behind. This pure turpentine is lefs golden-coloured, and is much more efteemed than the other. This procefs can only be done in the fummer.

To make *oil* of turpentine, an alembic, with a worm like what is ufed by the diftillers, is employed here. It generally contains 250lb. of turpentine, which is boiled gently, and kept at the boiling point till no more oil paffes, when the fire is damped. This generally gives 60lb. of oil, and the operation lafts one day.

The boiling turpentine, when it will give no more oil, is tapped off from the ftill and flows into a tub, and from thence into a mold of fand, which it fills, and is fuffered to cool for at leaft two days without difturbing it. This refidue is known under the name of *colophony*. It is of a brown colour, and very dry. It may be made clearer and nearer in colour to that of the refin, by adding hot water to it before it is tapped off the ftill, and ftill boiling and ftirring the water well with it, which is done with a befom of wet ftraw; and it is then fold for rofin, but is little efteemed, as it contains no effential oil.

TUSCULANUM, a villa belonging to Cicero, near Tufculum, where he wrote his *Quæftiones Tufculanæ*, fo named from the place; thus become famous as well for the productions of genius as of nature. Formerly the villa of Sylla: now called *Grotta Ferrata*.—Another *Tufculanum* (infcription), a town of the Tranfpadana, fituated on the weft fide of the Lacus Benatus. Now faid to be called *Tofcolano*, in the territory of Brefcia, fubject to Venice. Here many monuments of antiquity are dug up.

TUSCULUM (anc. geog.), a town of Latium, to the north of Alba; fituated on an eminence, and therefore called *Supernum* (Horace, Strabo). In fight of Rome, at about the diftance of 100 ftadia, or 12 miles. Adorned with plantations and princely edifices: The fpot remarkable for the goodnefs of the foil, and its plenty of water. Built by Telegonus, who flew his father Ulyffes (Ovid, Horace); called the grandfon of Ulyffes in Silius Italicus. A municipium (Cicero); the birth-place of the elder Cato (Nepos, Cicero). Now *Frefcati*, in the Campania of Rome.

TUTENAG, according to Sir George Staunton, is, properly fpeaking, zinc extracted from a rich ore, or calamine. The ore is powdered and mixed with charcoal-duft, and placed in earthen jars over a flow fire, by means of which the metal rifes in the form of vapour, in a common diftilling apparatus, and afterwards is condenfed in water. The calamine from which tutenag is thus extracted, contains very little iron, and no lead or arfenic, fo common in the calamine of Europe (See CALAMINE, *Encycl.*) Hence it is that tutenag is more beautiful than our zinc, and that the white copper of the Chinefe takes fo fine a polifh. See *White Copper*, in this *Supplement*.

TYERS (Thomas), an author both in poetry and profe, the friend of Johnfon, and well known to moft of the eminent characters of the prefent time, was a ftudent of the Temple in 1753. His father intended him for the law, but the young man it feems penned a fonnet when he fhould engrofs. He was an accomplifhed, but not a profound man; and had tafte and elegance of mind, flightly tinged with gleams of genius. He wrote fome paftorals and political tracts, which probably will not furvive the partiality of his particular friends.

TYPOGRAPHY, as the word imports, is the art of printing by types; but it is likewife ufed to fignify the multiplying of copies by any mechanical contrivance. Of the art of printing by types, and the many improvements from time to time either made or attempted in it, a pretty full account will be found in the *Encyclopædia*, under the titles LETTER, LOGOGRAPHY, and PRINTING; and in this *Supplement* under the word PRINTING. Of typography, in the other and larger fenfe, fome account may likewife be found in the *Encyclopædia* under the title *Method of Copying WRITINGS*; but to almoft all thefe articles there is ample room for fome additions here.

The *ftereotype* printing of *Didot* and *Herhan*, being confidered in France as a great improvement, muft not be paffed over wholly without notice. The term *ftereotype*

type is derived from the Greek words στερεος and τυπος, becauſe in this method the types are fixed and immoveable in the form, ſo that none of them can be pulled or diſplaced by the preſſman. We need hardly obſerve, to thoſe who are at all acquainted with the hiſtory of printing, that the project of foldering a whole form together, or of caſting a ſolid form from an impreſſion made by a general ſyſtem of types, or page ready compoſed, is not new. It was realiſed 70 years ago by William Ged, a goldſmith in Edinburgh; for an account of whoſe method we refer the reader to his life in the *Encyclopædia*. Didot now follows nearly the ſame proceſs as Ged. He does not indeed caſt his types in a maſs, but after the form is compoſed and carefully corrected, he cements or ſolders the types together ſo firmly that none of them is liable to be looſened by the action of the preſs or the adheſion of the balls. How far this method of printing is of value with regard to books which are altered and improved in every ſubſequent edition, may, perhaps, be queſtioned; but on a looſe conſideration of the ſubject, it ſeems as if it would, in every caſe, be advantageous to a bookſeller to print a few copies of a work, and keep the types ſtanding to print others as they may be wanted; —we ſay it would be advantageous, if it were not for the immenſe value in types, which would, by that means, be locked up. To form ſome judgment of this, it may be ſtated, that the works of Virgil, printed by Didot, in 18mo, form a beautiful volume of 418 pages, of 35 lines each. The character ranges line for line with that called burgeois, No 2. in Caſlon's book of ſpecimens, the face of the letter being rather ſmaller; and we are told* that the price of the plates of this work is twelve hundred franks, or 50l. ſterling. From this fact ſome judgment may be formed of the commercial queſtion. We have caſually looked at different books printed by Didot, but can ſay nothing of their correctneſs: the page is very pretty.

* *La Decade Philoſophique.*

For multiplying copies of any writing, or of a book of ordinary ſize, Rochon, of the French National Inſtitute, and now Director of the Marine Obſervatory at the port of Breſt, invented, about the year 1781, a machine for engraving, with great celerity and correctneſs, the pages of the book or manuſcript on ſo many plates of copper. It was ſubmitted to the examination of a committee of the Royal Academy of Sciences, whoſe report of its utility was given in the following words:

"This machine appears to us to unite ſeveral advantages. 1*ſt*, Engraved editions of books may be executed, by this means, ſuperior to thoſe which can be made by the hand of the engraver, however ſkilful; and theſe engraved originals will be made with much more ſpeed, and much leſs expence. 2*d*, As this machine is portable, and of no conſiderable bulk, it may become very uſeful in armies, fleets, and public offices, for the impreſſion of orders, inſtructions, &c. 3*d*. It poſſeſſes the advantage which, in a variety of circumſtances, is highly valuable, of being capable of being uſed by any man of intelligence and ſkill, without requiring the aſſiſtance of any profeſſional workman. And, *laſtly*, It affords the facility of waiting for the entire compoſition and engravings of a work before any of the copies are pulled off; the expence of plates, even for a work of conſiderable magnitude, being an object of little charge; and this liberty it affords to authors, may prove highly beneficial in works of which the chief merit conſiſts in the order, method, and connection of ideas."

Rochon's machine conſiſts of two braſs wheels*, placed on the ſame axis above each other, and ſeparated by a number of pillars, each two inches in length. Theſe two wheels, with the interval which ſeparates them, are equivalent to a ſingle wheel about three inches thick. In order therefore to ſimplify the deſcription, they are conſidered as a ſingle wheel which moves freely on its axis.

* See Plate XLVI.

This wheel is perforated near its circumference with a number of ſquare holes, which are the ſheaths or ſockets through which a like number of ſteel punches, of the ſame ſhape, are inſerted, and are capable of moving up and down. They are very well fitted; and from this circumſtance, as well as the thickneſs of the double wheel, they have no ſhake, or ſide motion, independent of the motion of the wheel itſelf. Every punch is urged upwards by a ſeparate ſpring, in ſuch a manner, that the wheel armed with its characters, or ſteel types, (the lower faces of the punches being cut into the figures of the ſeveral letters), may turn freely on its axis; and if it be moved, the ſeveral punches will paſs in ſucceſſion beneath an upright ſcrew, for preſſure. The ſcrew is fixed in a very firm and ſolid frame, attached to the ſupports of the machine; and by this arrangement a copperplate, diſpoſed on the table, or bed of the apparatus, will receive the impreſſion of all the punches in ſucceſſion, as they may be brought beneath the vertical preſſing ſcrew, and ſubjected to its action.

But as the preſs is fixed, it would neceſſarily follow that each ſucceſſive impreſſion would, in part, deſtroy or mutulate the previous impreſſions, unleſs the plate itſelf were moveable. It therefore becomes neceſſary that the plate ſhould be moveable in two directions: the firſt, to determine the interval between the letters and words, and form the lines; and the other motion, which is more ſimple, becauſe its quantity may remain the ſame through the whole of a book, ſerves to give the interval between line and line, and to form the pages.

It will eaſily be conceived that it would be a tedious operation to ſeek, upon the circumference of the wheel, each ſeveral character, as it might be required to come beneath the preſs, becauſe it is neceſſary to repeat this operation as many times as there are characters in a work. The author has conſiderably diminiſhed the time and trouble of this operation, by fixing upon the axis of the great wheel, which carries the punches, another ſmall wheel, about four inches in diameter, the teeth of which act upon a rack, which carries a rule moving between two ſliders. This rule, or ſtraight line, will therefore repreſent the developement, or unfolding of the circumference of the wheel which cauſes it to move, and will ſhew the poſition of the great wheel, which carries the punches. For theſe two wheels being concentric, the developement of the ſmall toothed wheel, of about two inches radius, will exhibit, in a ſmall ſpace (for example, that of a foot), an accurate regiſter of the relative poſitions of the punches with regard to the preſſing-ſcrew. To obtain this effect, nothing more is neceſſary than to place a fixed index oppoſite to the moveable rule, which laſt is divided in the following manner:

The

The punch on which the firſt letter of the alphabet is engraved, muſt be brought under the centre of the preſſing-ſcrew; and a line of diviſion then drawn upon the moveable rule, to which the letter itſelf muſt be added to diſtinguiſh it. The index, already mentioned, being placed oppoſite, and upon this firſt diviſion, will ſerve to place immediately beneath the preſſing-ſcrew the punch, or rather the character, correſponding with the diviſion upon the rule, without its being afterwards neceſſary to inſpect the place either of the punch or the ſcrew, with regard to each other. Conſequently, as ſoon as the diviſions which correſpond with all the punches inſerted in the wheel are engraved upon the ſtraight rule, the fixed index will immediately determine the poſition into which that wheel muſt be brought, in order to place the punches under the preſſing-ſcrew in the order which the work may require.

This regiſter, for this name diſtinguiſhes the rule and its index, has no other function in the machine than to guide the hand of the operator, and to ſhew when the punch is very near its proper poſition beneath the preſſing-ſcrew. When this is the caſe, the required poſition is accurately obtained by means of a detent or catch.

The detent which he uſes for this operation is a lever with two tails, one of which is urged toward the circumference of the wheel by a ſpring. To this extremity of the lever is fixed a piece of hardened ſteel, of the figure of a wedge, which, by means of a ſpring, is preſſed towards the axis of the great wheel, but may be relieved, or drawn back, by preſſure on the oppoſite tail of the lever, ſo as to permit the great wheel to revolve at liberty.

In the next place, it muſt be explained how this detent takes hold of the wheel, ſo as to retain it preciſely in the ſituation neceſſary to cauſe any one of the punches, at pleaſure, to give its impreſſion to the plate. For this purpoſe there are a number of notches cut in the circumference of the wheel, for the purpoſe of receiving the detent. Theſe notches may be about half an inch deep, wider towards the circumference than elſewhere, and it will be of advantage that this outer width ſhould be as great as the circumference of the wheel can conveniently allow. By this contrivance, the wedge will not fail to preſent itſelf oppoſite to one of the notches into which it will fall, and draw the wheel exactly to its due ſituation, even though the index of the regiſter ſhould not be brought preciſely to the line of diviſion appropriated to any particular letter. For if this laſt degree of preciſion were required in working the machine, it would be very prejudicial to the requiſite ſpeed which, above all things, is required in its uſe. When the wedge is therefore left at liberty, it not only enters immediately into its place, and moves the wheel till its two ſides apply fairly to the interior ſurfaces of the notch, but retains the wheel in this ſtate with the neceſſary degree of ſtability.

The method of giving the proper figure to theſe notches is very eaſy. For this purpoſe it is neceſſary, in the firſt place, to impreſs all the characters contained in the wheel on a plate of copper or pewter. The ſupport on which the plate is fixed muſt be moved in a right line, after each ſtroke of the punch, through ſuch a ſpace that the characters may be arranged one after the other without touching. Now, as the perfect linear arrangement (ſuppoſing every other part to be true) muſt depend on the notches, it might ſeem ſufficient to cut theſe according to the method uſed for the wheels of clock work: but as it is very difficult to avoid ſome obliquity on the face of the punch, and perhaps in the hole through which it paſſes, it is in almoſt every caſe neceſſary to retouch the notch itſelf. The requiſite degree of preciſion may be eaſily obtained, when, upon examining with attention the print of the characters engraven upon the plate, the inequalities ſhall have been aſcertained by a very fine line paſſing exactly under the baſe of two ſimilar letters, aſſumed as objects of compariſon: for the irregularity of linear poſition may, by this means, be determined with great exactneſs, and remedied to the moſt extreme nicety. In this operation, the workman muſt file away part of that ſurface of the notch which is oppoſite to the direction of the motion the character requires. Great care muſt be taken to file only a ſmall portion at a time, in order that the inſtant may be ſeized at which the wedge, by entering into the notch, brings the character to its due ſituation.

Theſe details, reſpecting the right-lined arrangement on the characters, muſt not divert our attention from the very great celerity with which any letter is brought to its place under the preſs by means of the regiſter and detent. This celerity is an object of ſo much importance in the engraving of a great work, that every means ought to be purſued which may tend to increaſe it. For this reaſon it is, that inſtead of following the alphabetic order in the arrangement of punches on the ſurface of the wheel, we ought to prefer that in which the ſum of the different motions to be given to the wheel, for engraving an entire work, ſhall be the leaſt poſſible. This tedious enquiry may well be diſpenſed with, by obſerving the order in which printers diſpoſe their caſes of characters, that the letters of the moſt frequent recurrence may be moſt immediately under the hand of the workman.

If all the characters afforded an equal reſiſtance to impreſſion in a plate of metal, a conſtant force would never fail to drive the punches to the ſame depth. But the faces of the letters are very unequal, and conſequently it will be neceſſary to uſe a variable force. Moſt workmen uſe the hammer, and not a ſcrew, as in this machine, for ſtamping. If the hammer had been uſed in this machine, it is evident, that if we ſuppoſed it to have fallen from the ſame height upon every one of the punches, the force of the ſtroke could be rendered variable according to the nature of the characters, by placing a capital, or head, upon each, of an height properly adjuſted to receive the hammer after paſſing through a greater or leſs ſpace. But the heads of our punches are variable at pleaſure, becauſe they are ſcrewed on; and thus it is that, by experimentally adjuſting the heads of all the punches, a ſet of impreſſions are obtained of equal depths from every one of them. When, for example, the letter *i* is placed under the hammer, the upper part of its head is at a ſmall diſtance from the head of the hammer, in order that its fall, which begins always at the ſame place, may ſtrike this letter weakly; but when the letter M is brought under the hammer, the upper part of its head being much leſs elevated than that of the letter *i*, will receive a much ſtronger blow. The impreſſions of the letters M and *i* will therefore always

ROCHON'S MACHINE FOR ENGRAVING METALLIC PLATES

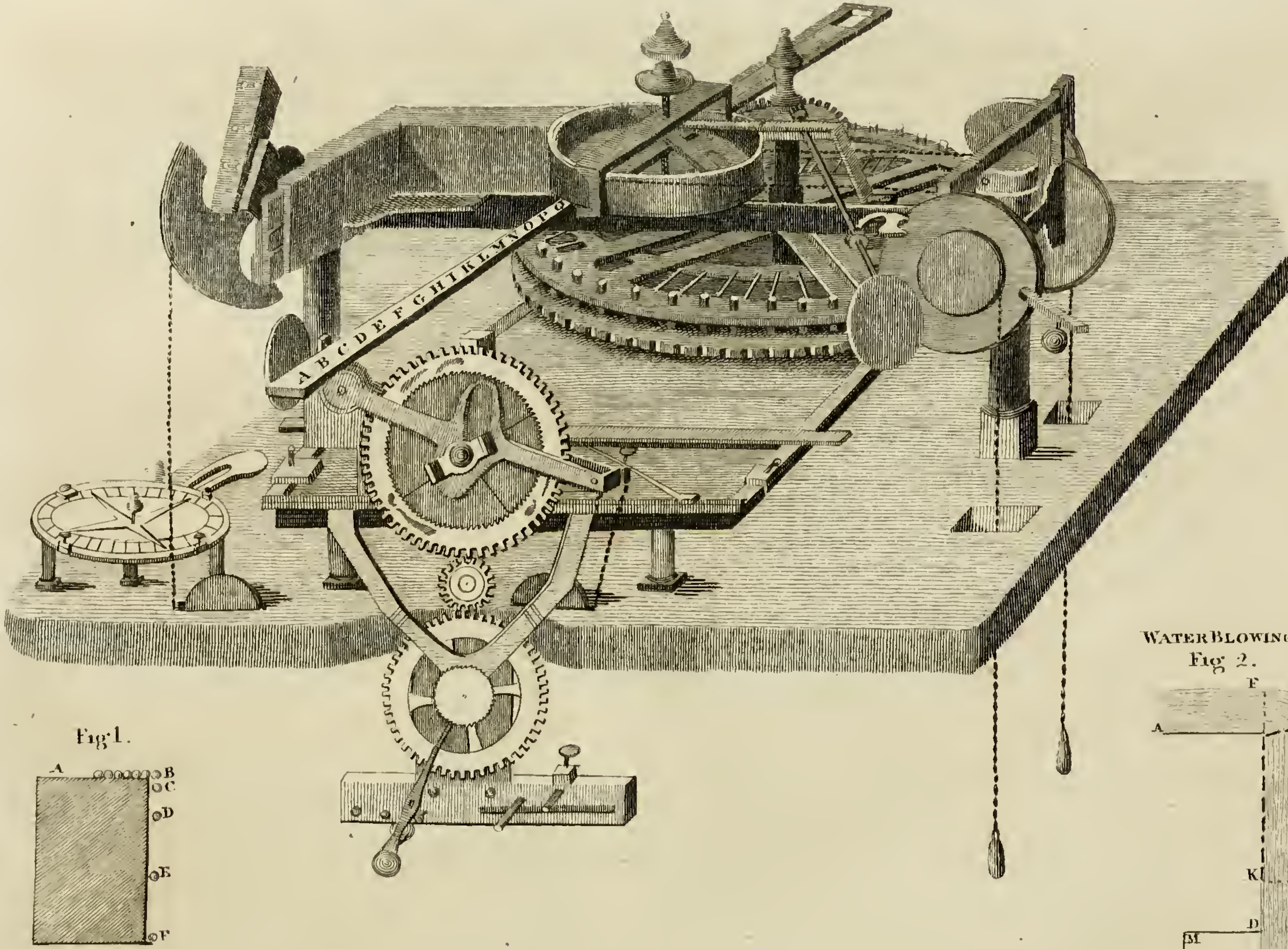
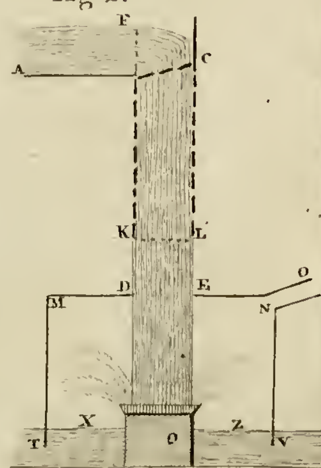


Fig 1.

WATER BLOWING
Fig 2.



ways be equally deep, if the heads of the punches be once properly fixed by experiment.

Instead of the stroke of a hammer, however, our author makes use of the pressure of a screw, of which the threads are so inclined that it runs through its female socket, and would fall out merely by its own weight. This construction affords the double advantage of preserving the impressions from the effects of the circular motion, and of affording a fall in the screw of nearly nine lines for each revolution. The head of this screw is solidly fixed in the centre of a brass wheel, of which the position is horizontal. The diameter of this wheel must be sufficiently large, that its motion may not be perceptibly affected by the irregularities of friction in the screw. This considerable diameter is also requisite, because the pressure of the screw depends, not only upon the force which is applied, but the distance of the place of application from the centre of movement.

It is essential that this wheel should have very little shake; for which reason it is advisable that the axis of the screw should be prolonged above the wheel itself, that it may slide in a socket firmly fixed to the frame of the machine. In this situation, the wheel, which is fixed on the prolongation of the screw, will have its plane constantly preserved in a situation parallel to itself, without any libration, notwithstanding the rise and fall of near nine lines, or three quarters of an inch, which it undergoes for each revolution on its axis.

It has been stated, as a requisite condition, that the screw should constantly fall from the same fixed point, or elevation, upon the heads of every one of the punches. To accomplish this essential purpose, a lever is firmly fixed to the support of the screw; which lever resembles the beam of a balance, having one of its extremities armed with a claw, and the other serving to give it motion through a small verticle space. The claw falls into a notch in the upper surface of the wheel attached to the screw, as soon as that wheel has risen to the desired elevation; and the lever itself is so far limited in its motion, that it cannot take hold of the wheel, excepting when it has reached that height. The wheel, therefore, remains confined and immoveable, by means of this detent, and cannot descend until it is delivered by pressure upon the opposite tail of the lever. In this machine, the wheel which has the pressing screw for its axis does not perform an entire revolution. It was with a view that there might never be any fall capable of shaking and disturbing the machine that the author determined to use only two-thirds of a revolution to strike those punches, which afford the strongest resistance. The screw consequently falls only through six lines upon those heads which are least elevated, and about two lines upon those which stand highest. Whence the difference between the extreme heights does not exceed four lines.

It is obvious, that so small a difference is not sufficient to strike all the characters from M to the letter *i*, when the wheel which governs the screw is put in motion by a constant weight, of which the impulse, like that of a hammer, is increased only by the acceleration of its fall. It is evident that this requisite variation of force might be had by changing the weight; but it is equally clear, that the numberless and incessant changes which the engraving of an entire work would demand, would be incompatible with that degree of speed which forms one of the first requisites. He was therefore obliged to render the force of the weight, which turns the screw, variable, by causing it to act upon levers of greater or less lengths, according to the different quantities of impulse required by the several punches. For this purpose he adopted the following construction: He connected by a steel chain to the wheel, which moves the screw, another wheel, having its axis horizontal, so that the two wheels respectively command each other. They are of equal diameter, and the chain is no longer than to make an entire turn round each wheel. This second wheel, or leading pulley, is intended to afford the requisite variations of force, which it does by means of a snail fixed upon its axis. The snail is acted upon by a cord passing over its spiral circumference, or groove, and bearing a weight which is only to be changed when a new set of punches for characters of a different size are put into the great wheel. The spiral is so formed, that when the weight descends only through a small space, the part of the cord, which is unwound, acts at a very short distance from the centre of the pulley; but when the fall is greater, the part of the snail upon which it acts is so far enlarged as to afford a much longer lever, and consequently, to give a proportionally greater effect to the stroke. This construction, therefore, by giving the advantage of a longer lever to a greater fall of the screw, affords all the power which the nature of the work, and the different spaces of the letters demand.

The support on which the plate is fixed must, as has before been remarked, move so as to form strait lines. This motion, which serves to space the different characters with precision, is obtained by means of a screw, the axis of which remains fixed, and carries a female screw or nut. The nut itself is attached to the support of the metallic plate, which receives the letters, and carries it in the right lined direction without any deviation; because it is confined in a groove formed between two pieces of metal. The screw is moved by a lever, which can turn it in one direction only, because it acts by a click upon a ratchet-wheel, which is fixed to the head of the screw. The action of this lever always begins from a fixed stop; but the space through which it moves is variable, according to the respective breadths of the letters. This new consideration induced M. Rochon to fix upon the rule or plate of the register, a number of pins, corresponding with the different divisions which answer to each punch: these pins determine the distance to which the lever can move. It therefore becomes a condition, that its position in the machine should be opposite to the fixed index which determines the character at any time beneath the pressing-screw. The lever and its pin are therefore the sole agents employed to space the characters. If the plate were not moved by the lever, the impressions would fall upon each other; and thus, for example, the letter *i* would be totally obliterated by the impression of the letter *l*.

Whenever, therefore, it is required to dispose the letters *i* and *l* beside each other, the plate must be moved after striking the letter *i* through a space equal to the quantity of the desired operation. Suppose this to be one-fourth of a line, and that the lever should run through an arc of ten degrees to move the plate thro' this quantity; as soon as the pin of the letter *l* shall be adjusted to the necessary length to enable the lever to describe an arc of ten degrees, the operation of spacing the

the two letters *i* and *l* will be reduced to that of placing the laſt letter beneath the fixed index, and moving the plate till the lever ſhall be ſtopped by the pin belonging to the letter *l*. All the other letters will be equally ſpaced, if the diſpoſition of the punches in the wheel be ſuch, that the laſt ſtroke of any letter ſhall confound itſelf with any letter of a ſingle ſtroke, ſuppoſing them to be impreſſed one after the other, without moving the lever between ſtroke and ſtroke. This arrangement deſerves to be very ſeriouſly attended to, becauſe the proceſs could not be performed without it.

Many well-informed perſons are of opinion, that the perfect equality which this machine for engraving affords in the formation of letters and ſigns the moſt difficult to be imitated, may afford a means of remedying the dangers of forgery. It is certain that the performance exhibits a ſimple and ſtriking character of preciſion, which is ſuch, that the leaſt experienced eyes might flatter themſelves, in certain caſes, to diſtinguiſh counterfeits from originals. Lavoiſier, whom the friends of ſcience and the arts will not ceaſe to regret, made ſome experiments of this kind for the *caiſſe de'ſcompte*, which were attended with perfect ſucceſs. Artiſts appointed for that purpoſe endeavoured in vain to imitate a vignette, formed by the ſucceſſive and equal motion of a character of ornament.

TYRTÆUS, an Athenian general and muſician, is celebrated by all antiquity for the compoſition of military ſongs and airs, as well as the performance of them. He was called to the aſſiſtance of the Lacedæmonians in the ſecond war with the Meſſenians, about 685 B. C.; and a memorable victory which they obtained over that people is attributed by the ancient ſcholiaſts upon Horace to the animating ſound of a new military flute or clarion, invented and played upon by Tyrtæus. Plutarch tells us that they gave him the freedom of their city; and that his military airs were conſtantly ſung and played in the Spartan army to the laſt hour of the republic. And Lycurgus the orator, in his oration againſt Leocrates, ſays, "The Spartans made a law, that whenever they were in arms, and going out upon any military expedition, they ſhould all be firſt ſummoned to the king's tent to hear the ſongs of Tyrtæus;" thinking it the beſt means of ſending them forth in a diſpoſition to die with pleaſure for their country. Fragments of his poetry, in elegiac verſe, are preſerved in Stobæus, Lycurgus Orat. in Fulvius Urſinus, at the end of Poems by illuſtrious Women; and in the Oxford edition of *Eleg. & Lyric Frag. & Scholia*, printed 1759. Εκ Συζομενα, &c.

TYTLER (William, Eſq;), ſo well known in the literary world as one of the ableſt, and certainly the moſt gentlemanly, of the defenders of the fame of Mary Queen of Scots, was born at Edinburgh, October 12. 1711. He was the ſon of Mr Alexander Tytler, writer (or attorney) in Edinburgh, by Jane, daughter of Mr William Leſlie, merchant in Aberdeen, and granddaughter of Sir Patrick Leſlie of Idan, provoſt of that city. He received his education at the grammar ſchool (or, as it is there called, the High School) and the univerſity of his native city, and diſtinguiſhed himſelf by an early proficiency in thoſe claſſical ſtudies, which, to the lateſt period of his life, were the occupation of his leiſure hours, and a principal ſource of his mental enjoyments.

In the year 1731, he attended the academical lectures of Mr Alexander Bayne, Profeſſor of municipal law in the univerſity of Edinburgh, a gentleman diſtinguiſhed alike for his profeſſional knowledge, his literary accompliſhments, and the elegance of his taſte. The Profeſſor found in his pupil a congenial ſpirit; and their connection, notwithſtanding the diſparity of their years, was ſoon ripened into all the intimacy of the ſtricteſt friendſhip. So ſtrong indeed became at length that tie of affection, that the worthy Profeſſor, in his latter years, not only made him the companion of his ſtudies, but when at length the victim of a lingering diſeaſe, choſe him as the comforter of thoſe many painful and melancholy hours which preceded his death.

At the age of 31, Mr Tytler was admitted into the Society of Writers to his Majeſty's Signet, and continued the practice of that profeſſion with very good ſucceſs, and with equal reſpect from his clients and the public, till his death, which happened on the 12th of September 1792. He married, in September 1745, Anne Craig, daughter of Mr James Craig of Dalnair, writer to the ſignet, by whom he has left two ſons, Alexander Fraſer Tytler, one of the Lords of Seſſion in Scotland; and Patrick Tytler, Lieutenant-colonel of a regiment of fencible infantry, and Fort-major of the caſtle of Stirling; together with one daughter, Miſs Chriſtina Tytler. His wife died about nine years before him; and, previouſly to that period, he had loſt a ſon and a daughter, both grown to maturity.

The moſt remarkable feature of Mr Tytler's character was an ardour and activity of mind, prompted always by a ſtrong ſenſe of rectitude and honour. He felt with equal warmth the love of virtue and the hatred of vice; he was not apt to diſguiſe either feeling, nor to compromiſe, as ſome men more complying with the world might have done, with the faſhion of the time, or the diſpoſition of thoſe around him. He ſeldom waved an argument on any topic of hiſtory, of politics, or literature; he never retreated from one on any ſubject that touched thoſe more important points on which he had formed a decided opinion. Decided opinions he always formed on ſubjects of importance; for on ſuch ſubjects he formed no opinions raſhly; and what he firmly believed he avowed with confidence, and ſometimes with warmth.

Nor was it in opinion or argument only that this warmth and ardour of mind were conſpicuous. They prompted him equally in action and conduct. His affection to his family, his attachment to his friends and companions, his compaſſion for the unfortunate, were alike warm and active. He was in ſentiment alſo what Johnſon (who felt it ſtrongly in himſelf, and mentions it as the encomium of one of his friends) calls a *good hater*; but his hatred or reſentment went no further than opinion or words, his better affections only roſe into action. In his opinions, or in his expreſſion of them, there was ſometimes a vehemence, an appearance of acrimony, which his friends might regret, and which ſtrangers might cenſure; but he had no aſperity in his mind to influence his actual conduct in life. He indulged oppoſition, not enmity; and the world was juſt to him in return. He had opponents; but two of his biographers, who knew him well, as well as the people with whom he moſt aſſociated, declare their belief that he had not a ſingle enemy. His conteſts were on opinions,

 nions, not on things; his difputes were hiftorical and literary. In converfation, he carried on thefe with uncommon intereft and vivacity; and the fame kind of impulfe which prompted his converfation (as is juftly obferved by an author, who publifhed fome notices of his life and character in the periodical work intitled *The Bee*) induced him to become an author. He wrote not from vanity or vain glory, which Rouffeau holds to be the only inducement to writing; he wrote to open his mind upon paper; to fpeak to the public thofe opinions which he had often fpoken in private; opinions on the truth of which he had firmly made up his own conviction, and was fometimes furprifed that he could not convince others: it was fair to try, if, by a fuller expofition of his arguments, he could convince the world.

With this view, he publifhed, in 1759, his "Inquiry, hiftorical and critical, into the Evidence againft *Mary Queen of Scots*, and an Examination of the Hiftories of Dr Robertfon and Mr Hume with refpect to that Evidence;" in which he warmly efpoufed the caufe of that unfortunate Princefs, attacked with feverity the conduct of her enemies, and expofed the fallacy, in many parts the fabrication, of thofe proofs on which the charges againft her had been founded.

This was a caufe worthy of an advocate who loved truth better than popular applaufe; and Mr Tytler evinced himfelf to be fuch an advocate. The problem of Mary's guilt or innocence, if confidered merely as a detached hiftorical fact, would appear an object which, at this diftance of time, feems hardly to merit that laborious and earneft inveftigation to which it has given rife; though, even in this point of view, the mind is naturally ftimulated to fearch out the truth of a dark myfterious event, difgraceful to human nature; and our feelings of juftice and moral rectitude are interefted to fix the guilt upon its true authors. But when we confider that this queftion involves a difcuffion of the politics of both England and Scotland during one of the moft interefting periods of their hiftory, and touches the characters, not only of the two fovereigns, but of their minifters and ftatefmen, it muft then be regarded in the light of a moft important hiftorical inquiry, without which our knowledge of the hiftory of our own country muft be obfcure, confufed, and unfatisfactory. In addition to thefe motives of inquiry, this queftion has exercifed fome of the ableft heads both of earlier and of later times; and it is no mean pleafure to engage in a conteft of genius and of talents, and to try our ftrength in the decifion of a controverfy which has been maintained on both fides with confummate ability.

As we have elfewhere (fee Mary, *Encycl.*) given an abftract of the arguments on both fides of this difputed queftion, it would be altogether improper to repeat them here; but juftice to the fubject of this memoir requires us to fay, that by his manner of difcuffing it he acquired high reputation in the republic of letters. Before the appearance of the Inquiry, fays an ingenious writer, it was the fafhion for literary difputants to attack each other like mifcreants and banditti. The *perfon* was never feparated from the *caufe*; and whatever attached the *one*, was confidered as equally affecting the *other*; fo that fcurrility and abufe blotted the pages even of a Bentley and a Ruddiman. The Hiftorical Inquiry was free from every thing of that fort: and though the higheft name produced not a mitigation of the force of any argument, the meaneft never fuffered the fmalleft abufe. He confidered it as being greatly beneath the dignity of a man contending for truth, to overftretch even an argument in the fmalleft degree, far more to pervert a fact to anfwer his purpofe on any occafion. In the courfe of his argument, he had too often occafion to fhew that this had been done by others; but he difdained to imitate them. His reafoning was forcible and elegant; impartially fevere, but always polite, and becoming the gentleman and the fcholar.

When this book appeared, it was univerfally read in Britain, and very well tranflated into French, under the title of "Recherches Hiftoriques et Critiques fur les Principales Preuves de l'Accufation intentée contre Marie Reine d'Ecoffe." The intereft it excited among literary men may be judged of from the character of thofe by whom it was reviewed on its publication, in the periodical works of the time. Dr Douglas, now Bifhop of Salifbury, Dr Samuel Johnfon, Dr John Campbell, and Dr Smollet—all wrote reviews of Mr Tytler's book, containing very particular accounts of its merits, and elaborate analyfes of the chain of its arguments. As an argument on evidence, no fuffrage could perhaps be more decifive of its merit than that of one of the greateft lawyers, and indeed one of the ableft men that ever fat on the woolfack of England, the late Lord Chancellor Hardwicke, who declared Mr Tytler's Inquiry to be the beft concatenation of circumftantiate proofs brought to bear upon one point that he had ever perufed. What effect that body of evidence, or the arguments deduced from it, ought to have upon the minds of thofe to whom the fubject may become matter of inveftigation, we do not prefume to determine. The opinion of the late Dr Henry, author of the Hiftory of Great Britain on a New Plan, may perhaps be thought neither partial nor confident. He fays, in a letter to Mr Tytler, publifhed in the firft volume of Tranfactions of the Antiquarian Society of Scotland, That he would be a bold man who fhould now publifh an Hiftory of Queen Mary in the fame ftrain with the two hiftorians (Mr Hume and Dr Robertfon), whofe opinions on the fubject the Inquiry had examined and controverted.

The moft exceptionable part of Mary's conduct, which, though it may admit of an apology, cannot be vindicated, is her marriage to Bothwell; and for that marriage Mr Tytler made an apology, founded on facts, which he would be a daring or very bigotted man who would attempt to controvert. See the article already referred to.

Befides the *Hiftorical Inquiry*, and the *Differtation on the Marriage of Queen Mary with the Earl of Bothwell*, our author publifhed feveral other works on hiftorical and literary fubjects; of which the firft was, the *Poetical remains of James I. King of Scotland*, confifting of *the King's Quier*, in fix cantos, and *Chrift's Kirk on the Green*; to which is prefixed a differtation on the Life and Writings of King James, in one volume 8vo, printed at Edinburgh in 1783. This differtation forms a valuable morfel of the literary hiftory of Europe; for James ranked ftill higher in the literary world as a *poet*, than in the political world as a *prince*. Great juftice is done to his memory in both refpects in this differtation: and the two morfels of poetry here refcued from oblivion will be efteemed by men of tafte as long as

Tytler.

as the language in which they are written can be underſtood (A).

2. "A diſſertation on Scottiſh Muſic," firſt ſubjoined to Arnot's hiſtory of Edinburgh. The ſimple melodies of Scotland have been long the delight of the natives, many of which, to them, convey an idea of pathos that can be equalled by none other; and are much admired by every ſtranger of muſical talents who has viſited this country. They have a powerful effect, indeed, when properly introduced, as a relief, into a muſical compoſition of complicated harmony. Theſe are of two kinds, pathetic and humorous. Thoſe who wiſh to receive information concerning this curious ſubject, will derive much ſatisfaction from the peruſal of this diſſertation. There is yet another kind of muſic peculiar to the Highlands of Scotland, of a more wild, irregular, and animating ſtrain, which is but ſlightly treated here, and requires to be ſtill more fully elucidated.

3. "Obſervations on the Viſion, a poem," firſt publiſhed in Ramſay's Evergreen, now alſo printed in the Tranſactions of the Society of Antiquaries of Scotland. This may be conſidered as a part of the literary hiſtory of Scotland.

4. "On the Faſhionable Amuſements in Edinburgh during the laſt century," *ibid.* It is unneceſſary to dwell on the light that ſuch diſſertations as theſe, when judiciouſly executed, throw upon the hiſtory of civil ſociety and the progreſs of manners. Mr Tytler was likewiſe the author of N° 16. of the Lounger, a weekly paper, publiſhed at Edinburgh in the year 1786. His ſubject is the Defects of Modern Female Education in teaching the Duties of a Wife; and he treats that ſubject like a maſter.

On all Mr Tytler's compoſitions the character of the *man* is ſtrongly impreſſed, which never, as in ſome other inſtances, is in the ſmalleſt degree contradicted by, or at variance with, the character of the *author*. He wrote what he felt, on ſubjects which he felt, on ſubjects relating to his native country, to the arts which he loved, to the times which he revered. His heart, indeed, was in every thing which he wrote, or ſaid, or did. He had, as his family and friends could warmly atteſt, all the kindneſs of benevolence: he had its anger too; for benevolence is often the parent of anger. There was nothing neutral or indifferent about Mr Tytler. In philoſophy and in hiſtory, he could not bear the coldneſs, or what ſome might call the temperance of ſcepticiſm; and what he firmly believed, it was his diſpoſition keenly to urge.

His mind was ſtrongly impreſſed by ſentiments of religion. His piety was fervent and habitual. He believed in the doctrine of a particular Providence, ſuperintending all the actions of individuals as well as the great operations of Nature: he had a conſtant impreſſion of the power, the wiſdom, and the benevolence of the Supreme Being; and he embraced, with thorough conviction, the truths of Chriſtianity.

His reading was various and extenſive. There was ſcarcely a ſubject of literature or taſte, and few even of ſcience, that had not at times engaged his attention. In hiſtory he was deeply verſed; and what he had read his ſtrong retentive memory enabled him eaſily to recal. Ancient as well as modern ſtory was familiar to him; and, in particular, the Britiſh hiſtory, which he had read with the moſt minute and critical attention. Of this, beſides what he has given to the public, a great number of notes, which he left in MS. touching many controverted points in Engliſh and Scottiſh hiſtory, afford the moſt ample proof.

In muſic as a ſcience he was uncommonly ſkilled. It was his favourite amuſement; and with that natural partiality which all entertain for their favourite objects, he was apt to aſſign to it a degree of moral importance which ſome might deem a little whimſical. He has often been heard to ſay, that he never knew a good taſte in muſic aſſociated with a malevolent heart: And being aſked, What preſcription he would recommend for attaining an old age as healthful and happy as his own? "My preſcription (ſaid he) is ſimple—ſhort but cheerful meals, muſic, and a good conſcience."

In domeſtic life, Mr Tytler's character was particularly amiable and praiſe worthy. He was one of the kindeſt huſbands and moſt affectionate fathers. At the beginning of this account, we mentioned his having loſt, at an advanced period of life, an excellent wife, and a ſon and a daughter both grown to maturity, who merited and poſſeſſed his warmeſt affections. The temper of mind with which he bore theſe loſſes, he has himſelf expreſſed in a MS. note, written not long before his death; with which, as it conveys a ſentiment equally important in the conſideration of this life, and in the contemplation of that which is to come, we ſhall conclude the preſent memoir: "The lenient hand of time (ſays he) after mentioning the death of his wife and children), the lenient hand of time, the affectionate care of my remaining children, and the duty which calls on my exertions for them, have by degrees reſtored me to myſelf. The memory of thoſe dear objects gone before me, and the ſoothing hope that we ſhall ſoon meet again, is now the ſource of extreme pleaſure to me. In my retired walks in the country I am never alone; thoſe dear ſhades are my conſtant companions! Thus what I looked upon as a bitter calamity, is now become to me the chief pleaſure in life."

U, V.

(A) There is a beautiful hiſtorical picture of this prince playing on the harp, with his queen and a circle of his courtiers liſtening to the muſic, by Graham, in London; one of the moſt eminent artiſts of the age.

U, V.

VACUUM Boyleanum, is the approach to a real vacuum, to which we can arrive by means of the air-pump.

Torricellian Vacuum, is the most complete vacuum which we can make by means of the torricellian tube. See Barometer, and Pneumatics, *Encycl.*

VADE-mecum, the title given to such books as men of particular professions, having frequent occasion to consult, may easily carry about with them. Thus a small volume, published in the beginning of the 18th century, giving an account of the ancient and present church of England, and of the duties, rights, privileges, and hardships of the clergy, is known by the title of *the Clergyman's Vade-mecum.*

VAKEEL, a minister, agent, or ambassador.

VALGUS, *Bow* or *Bandy Legged.* Some children are bow-legged from their birth; others become so from setting them on their feet too early. The tibia of some is crooked; the knees of others are distorted; from a fault in the ankle, the feet of some are turned inwards, these are called *vari;* and in others they turn outwards, these are called *valgi.* The best method of preventing these disorders in weakly children, is to exercise them duly, but not violently; by dancing or tossing them about in one's arms, and not setting them much on their feet, at least not without properly supporting them: if the disorder attends at the birth, or increases after it is begun, apply emollients, then apply boots of strong leather, wood, &c. as required to dispose the crooked legs gradually to a proper form: or other instruments may be used instead of boots, which, when not too costly, are usually to be preferred. Slighter instances of these disorders yield to careful nursing without instruments.

VANDA', the Indian name of a plant of the genus Epidendrum; which see, *Encycl.* The *vandá* is thus described by Sir William Jones.

"Cal. *Spathes* minute, straggling. Cor. *Petals* five, diverging, oval oblong, obtuse, wavy; the two lowest larger; the three highest equal, bent towards the nectary. *Nectary* central, rigid: *Mouth* gaping, oblique: *Upper lip* shorter, three parted, with a polished honey-cup; *under lip* concave in the middle, keeled above, with two smaller cavities below, two processes at the *base*, incurved, hollow, oval pointed, converging, honey-bearing. Stam. *Filaments* very short. *Anthers* round, flattish, margined, covered with a lid, easily deciduous from the *upper lip* of the nectary. Pist. *Germ.* beneath long, ribbed, contorted with curves of opposite flexure. *Style* very short, adhering to the *upper lip*. *Stigma* simple. Per. *Capsule* oblong-conic, wreathed, six-keeled, each with two smaller keels, three-celled, crowned with the dry corol. Seeds innumerable, like fine dust affixed to the *receptacle* with extremely fine hairs, which become thick wool. *Scapes* incurved, solitary, from the cavity of the leaf, at most seven flowered; pedicles alternate. *Petals* milk-white externally, transparent; brown within, yellow-spotted. *Upper lip* of the nectary snow-white; *under lip* rich purple, or light crimson, striated at the base, with a bright yellow gland, as it seems, on each process. The flowers gratefully fragrant, and exquisitely beautiful, looking as if composed of shells, or made of enamel; crisp elastic, viscid internally. *Leaves* sheathing, opposite, equally curved, rather fleshy, sword-form, retuse in two ways at the summit, with one acute point. *Roots* fibrous, smooth, flexible; shooting even from the top of the leaves."

This lovely plant attaches itself chiefly to the highest *Amras* and *Bilvas* (the *Mangifera* and *Crateva* of Lin.); but it is an air-plant, and lives (says the President) in a pot *without earth or water:* its leaves are excavated upwards, to catch and retain dew.

VANDALIA, a duchy of Farther Pomerania, subject to the king of Prussia. Stolpen is the capital.

Vandalia, a country in Germany, in the circle of Lower Saxony and duchy of Mecklenburg. It lies between the bishopric and duchy of Schwerin, the lordships of Stocrock and Stargard, Pomerania, and the marquisate of Brandenburg; and is 75 miles in length and 7 in breadth. It contains several small lakes, and the principal town is Gustrow.

VANDERMONDE, member of the National Institute of Sciences and Arts, was born at Paris in the year 1735. He devoted his youth to self-instruction; and even at the age of thirty was far enough from suspecting that he was destined to instruct others in his turn. Chance brought him near to the celebrated Fontaine. That sexagenary geometrician easily divined the progress which Vandermonde would one day make in the mathematics; in him he anticipated, as it were, a successor to himself; he patronised and caressed him, let him into the secret of his researches, calculations, inventions, of that lively enjoyment which profound speculation gives to an elevated attentive mind; and which, blended with the sweets of tranquillity, the charms of retreat, and the consciousness of success, becomes often a sort of passion, as felicitous as durable. All that time Fontaine, whose attention was again directed to the researches which he had added to those of Jean Bernouili, relative to the then famous question *of the toutocrones*, had the glory to be vanquished only by D'Alembert and La Grange. Vandermonde, a witness to this combat, necessarily illustrious, animated by the honour which he saw annexed to that glorious defeat, enchanted with the sight of Fontaine, as happy, in spite of his age, from his love of geometry, as a youth of twenty could be with a sentiment less tranquil, thought he should insure his happiness for ever, by yielding to a passion which the ice of age could not extinguish; in a word, he devoted himself to geometry.

His labours, however, were for some time secret; and perhaps the public would never have enjoyed the benefit of any of his works, if another geometrician (whose name, says Lacepede, cannot be pronounced, in this place, without a mixture of interest and regret) had not inspired him with a consciousness of his own strength, and courage to display it. Fontaine had already devoted him to geometry; Dusejour exhorted him to penetrate even into its sanctuary. In brief, he presented himself

Vandermonde.

himself to the Academy of Sciences, into which he was admitted in 1771; and in that very year justified the suffrages of his associates, by a paper which he published relative to the resolution of equations.

From the 16th century the method of resolving equations of the four first degrees has been known, and since that time the general theory of equations has received great improvements. In spite, however, of the recent labours of many great geometricians, the solutions of equations of the fifth degree had in vain been attempted. Vandermonde wished to consolidate his labours with those of other illustrious analysts; and he proposed a new theory of equations, in which he seems to have made it particularly his business to simplify the methods of calculation, and to contract the length of the *formulæ*, which he considered as one of the greatest difficulties of the subject.

This work was quickly followed by another on the problems called by geometricians *problems of situation*. It seems to have been the destiny of Vandermonde, as well as of Fontaine, who first initiated him into the mysteries of mathematical science, to labour frequently upon subjects already handled by the greatest master. In his first memoir he had started, so to speak, in competition with La Grange and Euler; in his second, with Euler and Leibnitz. This last was of opinion that the analysis made use of in his time, by the geometricians, was not applicable to all questions in the physical sciences; and that a new geometry should be invented, to calculate the relations of positions of different bodies, in space: this he called *geometry of situation**. Excepting, however, one application, made by Leibnitz himself, to the game of *solitaire*, and which, under the appearance of an object of curiosity, scarcely worthy the sublimity and usefulness of geometry, is an example for solving the most elevated and important questions, Euler was almost the only one who had practised this geometry of situation. He had resorted to it for the solution of a problem called the *cavalier*, which also appeared very familiar at first sight, and was also pregnant with useful and important applications. This problem, with the vulgar, consisted merely in running through all the cases of the chess board, with the *knight* of the game of chess; to the profound geometrician, however, it was a precedent for tracing the route which every body must follow, whose course is submitted to a known law, by conforming to certain required conditions, through all the points disposed over a space in a prescribed order. Vandermonde was chiefly anxious to find in this species of analysis a simple notation, likely to facilitate the making of calculations; and he gave an example of this, in a short and easy solution of the same problem of the cavalier, which Euler had rendered famous.

* See Position, *Suppl.*

His taste for the high conceptions of the speculative sciences, as blended with that which the *amor patriæ* naturally inspires for objects immediately useful to society, had led him to turn his thoughts towards perfecting the arts conversant in weaving, by indicating a manner of noting the points through which are to pass the threads intended to form the lines which terminate the surface of different regular bodies: accordingly a great part of the above memoir is taken up with this subject.

In the year following (1772) he printed a third memoir; in which he traced out a new path for geometers, discovering, by learned analytical researches, *irrational* quantities of a new species, shewing the sequels of which these *irrationals* are the terms or the sum, and pointing out a direct and general method of making in them all the possible reductions.

Vandermonde, Varenius.

In the same year appeared his work on the Elimination of unknown Quantities in Algebra. This elimination is the art of bringing back those equations which include many unknown quantities, to equations which only contain one. The perfection of researches in this art would consist in obtaining a general and particular *formula* of elimination in a form the most concise and convenient, in which the number of equations and their degrees should be designed by indeterminate letters. Vandermonde, while he considered the geometers as very distant from this point, had some glimpse of a possibility of reaching it, and proposed some new methods of approaching nearer it.

In 1778, he presented, in one of the public sittings of the Academy, a new system of harmony, which he detailed more fully in another public sitting of 1780. In this system, Vandermonde reduces the modes of proceeding adopted until his time, to two principal rules, which thus become established on effects admitted by all musicians. These two general rules, one on the succession of according sounds, the other on the arrangement of the parts, depend themselves on a law more elevated, which, according to Vandermonde, ought to rule the whole science of harmony.

By the publication of this work, he satisfactorily attained the end he had proposed to himself, and obtained the suffrages of three great men, representatives, so to speak, of the three great schools of Germany, France, and Italy; Gluck, Philidor, and Piccini.

With these labours, intermingled with frequent researches on the mechanic arts, as well as on objects of political economy, the attention of Vandermonde was taken up; when, July 14. 1789, the voice of liberty resounded over the whole surface of France, and suddenly all the thoughts, as well as all the affections, of Vandermonde, were engaged on the side of what he called liberty.

He became so furious a democrate, so outrageous an enemy to every thing established, that he concurred in the abolition of the Royal Academy, of which he had been so ambitious of becoming a member, and associated himself closely with Robespierre, Marat, and the rest of that atrocious gang of villains, who covered France with ruins, with scaffolds, and with blood. This part of Vandermonde's history is suppressed by his eulogist Lacepede, because, forsooth, discussions on *political opinions* ought not, in his opinion, to be admitted into the sanctuary of the sciences.

In that sanctuary he did not long remain. Soon after his atrocities, he was attacked by a disorder in his lungs, which almost taking away his breath, manifested itself by alarming symptoms, and conducted him by rapid steps to the tomb. He died in the end of the year 1795; a striking instance of the wayward violence of the human mind, which even the love of science could not keep at a distance from tumult and uproar.

VARENIUS (Bernard), a learned Dutch geographer and physician of the 17th century, who was author of the best mathematical treatise on geography, intitled, *Geographia Universalis, in qua affectiones generalis Telluris*

ris explicantur. This excellent work has been tranflated into all languages, and was honoured by an edition, with improvements, by Sir Ifaac Newton, for the ufe of his academical ftudents at Cambridge.

VARIABLE, in geometry and analytics, is a term applied by mathematicians to fuch quantities as are confidered in a variable or changeable ftate, either increafing or decreafing. Thus the abfciffes and ordinates of an ellipfis, or other curve line, are variable quantities; becaufe thefe vary or change their magnitude together, the one at the fame time with the other. But fome quantities may be variable by themfelves alone, or while thofe connected with them are conftant: as the abfciffes of a parallelogram, whofe ordinates may be confidered as all equal, and therefore conftant; alfo the diameter of a circle, and the parameter of a conic fection, are *conftant*, while their abfciffes are *variable*. See FLUXIONS, *Encycl.*

VARIATION OF CURVATURE, in geometry, is ufed for that inequality or change which takes place in the curvature of all curves except the circle, by which their curvature is more or lefs in different parts of them; and this variation conftitutes the quality of the curvature of any line.

1 Variolæ vaccinæ longknown in Gloucefterfhire,

VARIOLÆ VACCINÆ, or *Cow-pox*, is the name commonly, though as fome people think, improperly, given to a very fingular difeafe, which, for two or three years paft, has occupied a great fhare of the attention of medical men. It has been many years prevalent in fome of the great dairy counties in England, particularly Gloucefterfhire; and it has been long underftood by the farmers and others in thefe counties, that it for ever exempts all perfons who have been infected with it from the contagion of fmall-pox.

It is very furprifing that, though they knew this fact, and although no perfon had ever been known to die of the cow-pox, they never thought of having recourfe to a voluntary infection of this kind, in order to free themfelves and their families from the poffibility of being infected with the variolous poifon, which fo often proves mortal. In one cafe, indeed, communicated to Dr Pearfon by Mr Downe of Bridport, the experiment was long ago tried by a farmer upon his own perfon, and with complete fuccefs: But this only makes it the more wonderful that his example fhould not have been followed.

2 And in the duchy of Holftein.

In the town of Kiel, however, in the duchy of Holftein, where the difeafe is faid to be well known, as frequently affecting cows, we are told that children are fometimes inoculated with cow-pox *(Die Finnen)*, with a view to preferve their beauty; but that the people in the country do not like this inoculation, becaufe they pretend that it leaves behind it feveral diforders.

3 Vaccine inoculation introduced by Dr Jenner.

With thefe exceptions, Dr Jenner was the firft perfon who introduced the vaccine inoculation; and to him the public are alfo indebted for the firft careful and accurate inveftigation of this interefting fubject. The following is his account of the origin and hiftory of the difeafe, and of its characteriftic fymptoms.

4 Origin of the difeafe, according to him.

"There is a difeafe to which the horfe, from his ftate of domeftication, is frequently fubject. The farriers have termed it *the greafe*. It is an inflammation and fwelling in the heel, from which iffues matter poffeffing properties of a very peculiar kind, which feems capable of generating a difeafe in the human body (after it has undergone the modification which I fhall prefently fpeak of), which bears fo ftrong a refemblance to the fmall-pox, that I think it highly probable that it may be the fource of that difeafe.

"In this dairy county (Gloucefterfhire), a great number of cows are kept, and the office of milking is performed indifcriminately by men and maid fervants. One of the former having been appointed to apply dreffings to the heels of a horfe affected with *the greafe*, and not paying due attention to cleanlinefs, incautioufly bears his part in milking the cows with fome particles of the infectious matter adhering to his fingers. When this is the cafe, it commonly happens that a difeafe is communicated to the cows, and from the cows to the dairy maids, which fpreads through the farm until moft of the cattle and domeftics feel its unpleafant confequences. This difeafe has obtained the name of the cow-pox. It appears on the nipples of the cows in the form of irregular puftules. At their firft appearance they are commonly of a palifh blue, or rather of a colour fomewhat approaching to livid, and are furrounded by an eryfipelatous inflammation. Thefe puftules, unlefs a timely remedy be applied, frequently degenerate into phagedenic ulcers, which prove extremely troublefome. The animals become indifpofed, and the fecretion of milk is much leffened. Inflamed fpots now begin to appear on different parts of the hands of the domeftics employed in milking, and fometimes on the wrifts, which quickly run on to fuppuration, firft affuming the appearance of the fmall vefications produced by a burn. Moft commonly they appear about the joints of the fingers, and at their extremities; but whatever parts are affected, if the fituation will admit, thefe fuperficial fuppurations put on a circular form, with their edges more elevated than their centre, and of a colour diftantly approaching to blue. Abforptions take place, and tumors appear in each axilla. The fyftem becomes affected, the pulfe is quickened, and fhiverings, with general laffitude, and pains about the loins and limbs, with vomiting, come on. The head is painful, and the patient is now and then even affected with delirium. Thefe fymptoms, varying in their degrees of violence, generally continue from one day to three or four, leaving ulcerated fores about the hands, which, from the fenfibility of the parts, are very troublefome, and commonly heal flowly, frequently becoming phagedenic, like thofe from whence they fprung. The lips, noftrils, eyelids, and other parts of the body, are fometimes affected with fores; but thefe evidently arife from their being needlefsly rubbed or fcratched with the patient's infected fingers. No eruptions of the fkin have followed the decline of the feverifh fymptoms in any inftance that has come under my infpection, one only excepted; and in this cafe a very few appeared on the arms: they were very minute, of a vivid red colour, and foon died away without advancing to maturation: fo that I cannot determine whether they had any connection with the preceding fymptoms.

5 Its appearance on the cow and the perfon who milks her.

"Thus the difeafe makes its progrefs from the horfe to the nipple of the cow, and from the cow to the human fubject.

6 Its fingularity,

"Morbid matter of various kinds, when abforbed into the fyftem, may produce effects in fome degree fimilar; but what renders the cow-pox virus fo extremely fingular, is, that the perfon who has been thus affected

is

Variolæ Vaccinæ.

is for ever after fecure from the infection of the fmall-pox; neither expofure to the variolous effluvia, nor the infertion of the matter into the fkin, producing this diftemper.

7
Though it is fometimes confounded with another difeafe.

"It is neceffary to obferve, that puftulous fores frequently appear fpontaneoufly on the nipples of cows; and inftances have occurred, though very rarely, of the hands of the fervants employed in milking being affected with fores in confequence, and even of their feeling an indifpofition from abforption. Thefe puftules are of a much milder nature than thofe which arife from that contagion which conftitutes the true cow-pox. They are always free from the bluifh or livid tint fo confpicuous in that difeafe. No eryfipelas attends them, nor do they fhew any phagedenic difpofition, as in the other cafe, but quickly terminate in a fcab, without creating any apparent diforder in the cow. This complaint appears at various feafons in the year, but moft commonly in the fpring, when the cows are firft taken from their winter food and fed with grafs. It is very apt to appear alfo when they are fuckling their young. But this difeafe is not to be confidered as fimilar in any refpect to that of which I am treating, as it is incapable of producing any fpecific effects on the human conftitution. However, it is of the greateft confequence to point it out here, left the want of difcrimination fhould occafion an idea of fecurity from the infection of the fmall-pox, which might prove delufive."

Dr Jenner adds, that the active quality of the virus from the horfe's heels is greatly increafed after it has acted on the nipples of the cow, as it rarely happens that the horfe affects his dreffer with fores, and as rarely that a milkmaid efcapes the infection when fhe milks infected cows. It is moft active at the commencement of the difeafe, even before it has acquired a pus-like appearance. Indeed the Doctor is rather induced to think that the matter lofes this property entirely as foon as it is fecreted in the form of pus, and that it is the thin darkifh-looking fluid only, oozing from the newly formed cracks in the heels, fimilar to what fometimes exudes from eryfipelatous blifters, which gives the difeafe. He is led to this opinion, from having often inferted pus taken from old fores in the heels of horfes, into fcratches made with a lancet, on the found nipples of cows, which has produced no other effect than fimple inflammation.

He is uncertain if the nipples of the cow are at all times fufceptible of being acted upon by the virus from the horfe, but rather fufpects that they muft be in a ftate of predifpofition, in order to enfure the effect. But he thinks it is clear that when the cow-pox virus is once generated, the cows, when milked with a hand really infected, cannot refift the contagion, in whatever ftate their nipples may chance to be. He is alfo doubtful whether the matter, either from the cow or the horfe, will affect the found fkin of the human body; but thinks it probable that it will not, except on thofe parts where the cuticle is very thin, as on the lips.

At what period the cow-pox was firft noticed in Gloucefterfhire is not upon record. The oldeft farmers were not unacquainted with it in their earlieft days when it appeared upon their farms, without any deviation from the phenomena which it now exhibits. Its connection with the fmall pox feems to have been unknown to them. Probably the general introduction of inoculation firft occafioned the difcovery. Dr Jenner conjectures that its rife in that neighbourhood may not have been of very remote date, as the practice of milking cows might formerly have been in the hands of women only; and confequently the cows might not in former times have been expofed to the contagious matter brought by the men fervants from the heels of horfes. He adds, that a knowledge of the fource of the infection is new in the minds of moft of the farmers, but has at length produced good confequences; and that it feems probable, from the precautions they are now difpofed to adopt, that the appearance of the cow-pox in that quarter may either be entirely extinguifhed or become extremely rare.

With refpect to the opinion adduced (Dr Jenner obferves), that the fource of the infection is a peculiar morbid matter arifing in the horfe; although I have not (fays he) been able to prove it from actual experiments conducted immediately under my own eye, yet the evidence I have adduced appears to eftablifh it.

"They who are not in the habit of conducting experiments, may not be aware of the coincidence of circumftances, neceffary for their being managed fo as to prove perfectly decifive; nor how often men engaged in profeffional purfuits are liable to interruptions, which difappoint them almoft at the inftant of their being accomplifhed; however, I feel no room for hefitation refpecting the common origin of the difeafe, being well convinced that it never appears among the cows, except it can be traced to a cow introduced among the general herd which has been previoufly infected, or to an infected fervant, unlefs they have been milked by fome one who, at the fame time, has the care of a horfe affected with difeafed heels."

The following cafe, which we alfo quote from Dr Jenner, would feem to fhew that not only the heels of the horfe, but other parts of the body of that animal, are capable of generating the virus which produces the cow-pox.

"An extenfive inflammation of the eryfipelatous kind appeared, without any apparent caufe, upon the upper part of the thigh of a fucking colt, the property of Mr Millet, a farmer at Rockhampton, a village near Berkeley. The inflammation continued feveral weeks, and at length terminated in the formation of three or four fmall abfceffes. The inflamed parts were fomented, and dreffings were applied by fome of the fame perfons who were employed in milking the cows. The number of cows milked was twenty-four, and the whole of them had the cow-pox. The milkers, confifting of the farmer's wife, a man, and a maid fervant, were infected by the cows. The man-fervant had previoufly gone through the fmall-pox, and felt but little of the cow-pox. The fervant maid had fome years before been infected with the cow-pox, and fhe alfo felt it now in a flight degree: but the farmer's wife, who never had gone through either of thefe difeafes, felt its effects very feverely. That the difeafe produced upon the cows by the colt, and from them conveyed to thofe who milked them, was the *true* and not the *fpurious* cow-pox, there can be fcarcely any room for fufpicion; yet it would have been more completely fatisfactory had the effects of variolous matter been afcertained on the farmer's wife; but there was a peculiarity in her fituation which prevented my making the experiment."

Subfequent

Variolæ Vaccinæ.

8 Dr Jenner's opinion of the origin of the disease controverted.

Subsequent authors have not been all disposed to adopt Dr Jenner's opinion that this disease derives its origin from the grease in horses. We have seen the Doctor himself allow that he has not been able to prove it decisively by actual experiments; and to establish a fact so contrary to all analogy, perhaps no weaker evidence ought to be admitted. The only other bestial disorder with which we are acquainted, which is capable of being communicated by contagion to the human species, is hydrophobia: but here the disorder is the same in man as in the animal from which he derives it; and the analogy holds good in the propagation of the vaccine disease from the cow to her milker. But that the discharge from a local disease in the heel of a horse should be capable of producing a general disorder in the constitution of a cow, with symptoms totally different, and that this new disease once produced should be capable of maintaining an uniform character in the cow and in man, seems a much greater departure from the ordinary proceeding of Nature. We are very far from saying that this is impossible; for little indeed do we know of what Nature can or cannot do. All we mean to say is, that a fact so very extraordinary ought not to be hastily admitted.

In Holstein, we are told that the farmers do not know of any relation existing between the grease and the cow-pox, at least a person who resided three years in that country never heard of any. This, however, is certainly no proof. The same communication which contains this remark (a letter from Dr De Carro of Vienna to Dr G. Pearson) adds, "that in great farms men do not milk cows, but that in the smaller ones that happens very often; that a disease of horses, called *mauke* (true German name for *grease*), is known by all those who take care of them; that old horses particularly, attacked with the mauke, are always put in cow's stables, and there are attended by women; and that it is particularly in harvest that men in small farms milk cows." It must be allowed, then, that in this situation, supposing Dr Jenner's opinion well founded, the cow-pox was naturally to be looked for, and here accordingly we find it. The question is certainly of no real utility, and therefore it has very properly been less attended to than other points respecting this disorder which lead to important practical conclusions.

Of all the questions which have arisen relative to the cow-pox, there is none so interesting, and luckily there is none which has received so full a discussion, or so satisfactory an answer, as the one we are now about to consider. Are those persons who have once had the cow-pox effectually and for ever secured against the variolous contagion?

9 A previous attack of this disease renders the body unsusceptible of small-pox.

Dr Jenner, in his first publication, was decidedly of opinion that a previous attack of this disorder rendered the human body for ever unsusceptible of the variolous virus; and besides the universal popular belief in the countries where cow-pox is known, he brought forward a number of cases in support of his assertion. By some of these it appeared that persons who had been affected with the cow-pox above twenty or thirty years before continued secure against infection, either by the effluvia from patients under small-pox, or by inoculation. But along with this opinion he entertained other two, which, to many people, appeared so surprising as to take away all credit from the former. The first was, that a previous attack of small-pox did not prevent a subsequent attack of cow-pox; and the second was perhaps still more wonderful, that the cow-pox virus, although it rendered the constitution unsusceptible of the small-pox, should nevertheless leave it unchanged with respect to its own action, for that the same person is susceptible of repeated attacks of the cow pox.

Variolæ Vaccinæ.

10 Difficulties explained.

These opinions have been submitted to the test of very extensive experience by a variety of intelligent practitioners; and we think there can now be little doubt that the two last are erroneous, while the truth of the first has been established by an immense body of incontrovertible evidence.

The opinions that a person who has had the small-pox may afterwards have the cow-pox, and that the same person may have the cow-pox more than once, probably arose from the distinction between the local effects of the vaccine virus, and the general disorder of the constitution not having been sufficiently attended to. It is generally admitted, that in the inoculated small pox the local affection may go so far as that a pustule shall arise on the part, containing matter capable of communicating the true small-pox to others, and yet, if no general affection of the constitution takes place, the patient is not secure from the disorder. In like manner, there are cases upon record which prove that a person may, after having had the small-pox, have a local affection produced by inoculation, in which true variolous matter shall be formed capable of communicating both the local and constitutional symptoms of small-pox to others; and nurses, when much exposed to variolous contagion, often have an eruption resembling small-pox upon such parts of their skin as have been exposed to the action of the virus, though they have formerly undergone the disease. Yet there is probably no person at this day who will go so far as to assert that the same person can have the specific variolous fever more than once.

The case seems to be precisely the same with respect to cow-pox. Dr Pearson and others have inoculated a number of persons after they have had the small-pox with the vaccine virus, and have produced only the local affection; and by the same test it is ascertained that the same person cannot more than once have the constitutional symptoms of the cow-pox. Dr Woodville indeed tells us that he has seen one case of genuine cow-pox pustule and specific fever in a constitution which had previously suffered the small pox. There can be no higher authority on this subject than that of Dr Woodville; and if he had actually seen his patient in the small-pox as well as the cow-pox, we should have admitted this single case as completely decisive of the question. But the only evidence of this person having had the small-pox, is the assertion of the patient that he had it *when a child*. This we can by no means sustain as conclusive in opposition to the Doctor's own experience, as well as the experience of Dr Pearson.

That the milkers are subject to repeated attacks of the local symptoms of cow-pox, whether they have had the small-pox or not, is certain. In the case of the farmer's servants at Rockhampton, which we have quoted above from Dr Jenner, one of whom had previously undergone the small-pox, and the other the cow-pox, and both of whom were afterwards infected by by the cow-pox *in a ſlight degree*, it ſeems reaſonable to conclude that the local ſymptoms only were preſent in the laſt attack. We may at the ſame time obſerve, that in a caſe of this kind, where a very painful ulcer is produced in a very ſenſible part, this may probably be attended by an increaſed frequency of pulſe; yet if this has not the ſpecific marks of the cow-pox fever, we ſhould not ſay that ſuch a perſon has the diſorder conſtitutionally.

11 Succeſs of vaccine inoculation. With reſpect to the principal propoſition, that the ſpecific fever of cow-pox renders the conſtitution unſuſceptible of the variolous fever, we think no doubt now remains. About 1000 perſons who have undergone the vaccine inoculation have been afterwards inoculated with variolous matter, which has produced no other than local effects. Beſides theſe, there have been a vaſt number inoculated by private practitioners in different parts of the kingdom, the reſult of which has not been reported. But we may ſafely ſuppoſe, that if any one of them had afforded a concluſion oppoſite to the one now generally admitted, it would have been communicated to the public.

We muſt not, however, conceal one ſeemingly well authenticated caſe which has lately occurred, and which, ſo far as it goes, certainly militates againſt this concluſion, and which, we doubt not, will be eagerly caught at by the opponents of the new practice. We quote it from the Medical and Chirurgical Review for September 1800.

12 A ſeemingly well authenticated exception. "Mr Malim, ſurgeon of Carey Street, London, inoculated a child, two years and an half old, with vaccine matter procured from Dr Jenner. On the third day there were ſufficient marks of the action of the virus, and from this time to the end of the diſeaſe the local affection proceeded regularly and without interruption. On the eighth day the child complained of headache and ſickneſs; had a quick pulſe, white tongue, and increaſed heat, with an enlargement and tenderneſs in the axilla. Theſe ſymptoms ſubſided in the courſe of the next day, and the child remained well till the twelfth, when it had a very ſevere attack of fever, ſucceeded, the following day, by an irruption; the appearance, progreſs, and termination of which, left no doubt in the minds of ſeveral eminent practitioners of its being the ſmall-pox. That it was really ſo, has been ſince clearly proved by inoculation. There was a child ill of ſmall-pox in the houſe at the time the above inoculation for cow-pox was performed."

The Reviewers juſtly remark, that the hiſtory is defective, in not deſcribing more minutely the appearances of the inoculated parts at the different ſtages, as well as in not mentioning the length of time that the matter had been taken previous to being uſed. Both theſe points are the more important, as a ſuſpicion naturally ariſes, that the local affection which ſucceeded the vaccine inoculation was not the genuine cow-pox puſtule, but one of the ſpurious kind, which had not the power of deſtroying variolous ſuſceptibility. The matter having been furniſhed by Dr Jenner, no doubt, renders this ſuppoſition the leſs probable; but if it was either long or improperly kept after it came out of his hands, it may have undergone a material change, by putrefaction or otherwiſe. Dr Jenner mentions an inſtance of a practitioner, who had been accuſtomed to preſerve variolous matter in a warm pocket; a ſituation favourable for producing putrefaction in it. This matter, when inſerted, was found to produce inflammation, ſwellings of the axillary glands, fever, and ſometimes eruptions; but not of the true variolous kind, as patients thus inoculated were found ſtill ſuſceptible of the ſmall-pox contagion. It is ſurely a poſſible ſuppoſition, tho' merely a conjecture, that the vaccine matter in Mr Malim's caſe had undergone ſome ſuch change.

The caſe, however, is in ſeveral reſpects an intereſting one. As it has been ſuppoſed that variolous contagion, communicated in the form of exhalation, does not affect the conſtitution in leſs than fourteen or fifteen days, and as the vaccine matter, communicated by inoculation, produces its ſpecific effects ſome days earlier, it has been ſuggeſted, that wherever a perſon has been accidentally expoſed to variolous effluvia, we ſhould endeavour to anticipate the ſmall pox by immediately inoculating with the vaccine virus. But if there be nothing falacious in the above caſe, it appears that this meaſure would not ſtop the progreſs of the ſmall-pox, but that our patient would incur the additional danger of having two diſeaſes inſtead of one.

At all events, it muſt be allowed that this child had been infected by the ſmall-pox before the vaccine matter had begun to produce its ſpecific effects, and probably even before the inoculation. Thus the ſmall-pox may be conſidered as having begun before the cow-pox; and though we ſhould be forced to allow that, matters being thus ſituated, the latter diſorder could not prevent the farther progreſs of the former, it by no means follows, that when the cow-pox has fairly run its courſe, the conſtitution is ſtill ſuſceptible of ſmall-pox. The two diſeaſes muſt have exiſted in this patient at the ſame time, though the one was in a latent ſtate during the active ſtage of the other. 13 Probably accounted for.

This ſolitary caſe, then, is by no means concluſive, and certainly is not ſufficient to outweigh the immenſe maſs of concurring evidence which is oppoſed to it.

We proceed now to another highly important branch of our ſubject—the compariſon of the advantages and diſadvantages of the two diſeaſes, with a view to the practice of inoculation. 14 Advantages of the new practice.

Notwithſtanding the immenſe number of caſes in which the inoculation of the cow-pox has been tried, we are not yet fully qualified to appreciate the value of the new practice; becauſe the diſeaſe has varied very much in ſeverity, and even in its moſt remarkable ſymptoms, and that without any cauſe which has yet been diſcovered.

Dr Jenner's account of the diſeaſe gave us reaſon to think, that the local affection in cow-pox was more ſevere than in the inoculated ſmall-pox; that the fever in this diſeaſe was never attended with dangerous ſymptoms; that thoſe ſymptoms which affect the patient with ſeverity are entirely ſecondary, excited by the irritating proceſſes of inflammation and ulceration; that the diſeaſe was not attended with any eruption reſembling ſmall-pox; and that the ſore produced by the inoculation was apt to degenerate into a very diſtreſſing phagedenic ulcer, which required to be treated with applications of a cauſtic nature, of which he found the unguentum hydrargyri nitrati the moſt uſeful.

Soon after Dr Jenner's publication, the attention of medical men was forcibly drawn to the ſubject; and ſeveral eminent practitioners in London, particularly Dr George

Variolæ Vaccinæ.

George Pearfon, and Dr Woodville phyfician to the fmall-pox and inoculation hofpitals, immediately began to practife the vaccine inoculation. The latter gentleman foon publifhed an accurate and candid account of the effect of this virus upon 200 patients, with a table of the refults of above 500 cafes in which the inoculation was performed.

15 Anomalies in the progrefs of the difeafe.

It is very remarkable, that in none of thefe cafes did the inoculated part ulcerate in the manner defcribed by Dr Jenner, nor did the inflammation ever occafion any inconvenience, excepting in one inftance, in which it was foon fubdued by the aqua lythargyri acetati. The general affection of the conftitution, on the other hand, though in a great majority of cafes it was very flight, yet, in fome inftances, was fevere. An eruption, exactly refembling fmall-pox, was, contrary to expectation, a very common occurrence, and in fome the puftules were not fewer than 1000; and although in thefe cafes the difeafe was ftill unattended with fecondary fever, yet the febrile fymptoms which took place from the commencement were confiderable, and even alarming, as fometimes alfo happens with the inoculated fmall-pox.

Dr Woodville fometimes inoculated with matter from the primary fore in the arm, and fometimes with matter taken from the puftular eruption; and it appears from the table that a much larger proportion of thofe who were inoculated in the latter way had puftules, than of thofe who were inoculated either with matter immediately from the cow, or from the primary fore in the human body. There were 447 patients in all inoculated, either from the cow or from the primary fore; and of thefe 241 had puftules, and 206 had none. Sixty-two perfons, on the other hand, were inoculated with matter from the puftules of ten different patients; and of thefe no fewer than 57 had puftules, and only 5 efcaped without. Nor can it be faid that this difproportion arofe from thefe 10 patients having the difeafe in a more virulent form than ordinary, for matter was alfo taken from the primary fore in 4 of the 10, with which 48 were inoculated; of whom 27 had puftules, and 21 had none: whereas, of 9 perfons who were inoculated with matter from the puftules of thefe fame 4, only 2 efcaped without puftules. This obfervation correfponds alfo with Dr Pearfon's experience.

Although thefe eruptions have been met with by other practitioners, yet they certainly appear very rarely in private practice. Dr Woodville, for this reafon, confiders them, in a more recent publication, as the effect of fome adventitious caufe, independent of the cow-pox: And this he fuppofes to be the variolated atmofphere of the hofpital, which thofe patients were neceffarily obliged to infpire during the progrefs of the cow-pox infection. This opinion, however, does not feem to agree well with his former remark, which, as we have faid, is confirmed by Dr Pearfon, that eruptions rarely took place, if care was taken to avoid matter for inoculation from fuch as had puftules; a fact that cannot be explained on fuch a fuppofition. Neither is this idea reconcileable with what he alfo tells us, that the proportion of cafes in the hofpital attended with puftules has been of late only three or four in a hundred.

This change in the appearances of the difeafe in the hands of different practitioners, and even of the fame practitioner at different times, is one of the moft unaccountable circumftances refpecting this fingular diforder. There is fome curious information on this fubject, contained in a letter from Mr Stromeyer of Hanover to Mr Hannehmann.

"This year (fays he) we have inoculated 40 perfons, as well with the vaccine matter received of Dr Pearfon as with that from Dr Jenner; all of whom underwent the difeafe properly.

"Betwixt the London and Gloucefter vaccine matter, it appears to me there fubfifts an effential difference. The London matter produces frequently an eruption of fmall pimples; but they difappear within a day or two at fartheft. Dr Pearfon calls thefe eruptions *puftules*.—The Gloucefter matter has never produced this effect here; but *frequently occafioned ulcerations of the inoculated part, of a tedious and long duration; which the latter never did*: on account of which I now only make ufe of Dr Pearfon's vaccine matter. The nettle-fever like eruptions I have obferved feveral times, but never that fort of eruption, repeatedly noticed in London, which fo much refembles the fmall-pox."

If thefe obfervations of Mr Stromeyer fhould be confirmed by the experiments of others, they would go far to explain the difference which the London practitioners have found in this difeafe from the account given of it by Dr Jenner, notwithftanding the abfence of the eruption refembling fmall-pox at Hanover. We believe an interchange of vaccine matter has once or twice taken place between London and Gloucefterfhire. Is it fince that period that the eruption has been lefs frequent at London? Dr Pearfon is inclined to fuppofe, that the comparative feverity of the difeafe at London, during the firft winter, arofe rather from the difference in the human conftitution at the different feafons of the year, than from any change in the ftate of the vaccine matter.

16 Mortality for the old practice over-rated by the advocates for the new.

In comparing the degree of danger from the inoculation of cow-pox with that arifing from the inoculated fmall pox, we are convinced that Dr Pearfon greatly over-rates the mortality in the latter diforder. He fuppofes it to be no lefs than one in 200. Dr Mofeley, on the other hand, who is a violent opponent of the vaccine inoculation, afferts, that he has inoculated feveral thoufands with variolous matter, in Europe and the Weft Indies, without ever lofing a patient, and that feveral other perfons, whom he knows, have done the fame, with the fame fuccefs. We are afraid, however, that the experience of other inoculators does not afford fo favourable a refult. We believe that in this country the mortality is often occafioned by improper treatment; and from comparing the accounts which we have received from practitioners of extenfive experience, and undoubted veracity, we believe that, where the treatment is proper from the beginning, the fymptoms very rarely arife to an alarming height, and that the mortality is not fo great as one in 600. And this eftimate nearly correfponds with Dr Woodville's very great experience. It muft be allowed, that patients in an hofpital are fubject to fome difadvantages, which may be avoided in private practice; yet, out of the laft 5000 cafes of variolous inoculation at the inoculation hofpital, prior to the publication of the Doctor's reports, the mortality did not exceed one in 600.

Notwithftanding this ftatement, however, we are happy

Variolæ Vaccinæ. py to say, that the danger in the vaccine disease is still much less. Dr Pearson tells us, that in little more than six months after the new inoculation was introduced into London, which includes the period at which the cow-pox assumed the most unfavourable appearance, 2000 persons at least underwent the operation; of these, one only, an infant at the breast, under the care of Dr Woodville, died. In this solitary fatal case, the local tumor was but very inconsiderable; and the eruptive symptoms took place on the seventh day, when the child was attacked with fits of the spasmodic kind, which recurred at short intervals, with increased violence, and carried it off on the eleventh day after the cow-pox matter had been infected into its arm, and after an eruption of about 80 pustules had appeared.

17 Great success of the new inoculation.

Since that time a much greater number, amounting certainly to several thousands, have been inoculated with cow-pox in different parts of Great Britain and on the continent. Among these, not one fatal instance, that we have heard of, has occurred.

But even if the danger to the individual from the small-pox and from the cow-pox were equal, there is an important advantage to the public attending the latter, which we think would alone be sufficient to intitle it to a preference—It is not capable of being propagated by the effluvia arising from the bodies of persons infected with it. There are many situations in which a prudent surgeon will be restrained from inoculating with small-pox, lest the contagion should spread to other people, who may be either prevented by prejudice from submitting to the operation, or in whom it would be obviously improper, from the circumstances of age, teething, or the presence of some other disease. Here the cow-pox virus may be substituted with great propriety. It is chiefly from this quality that the cow-pox bids fair to extirpate the small-pox entirely.

This valuable property of the vaccine disorder is not, however, to be admitted without some limitation. When it produces numerous pustules on the body, Dr Woodville tells us, that the exhalations they send forth are capable of affecting others, in the same manner as the small-pox. Two instances of casual infection in this way have fallen under his observation. In one, the disease was severe, and the eruption confluent; in the other, the disease was mild, and the pustules few. It has been remarked, that the inoculated cow pox is little, if at all, different from the disease when casually caught. But, strictly speaking, the above are the only two cases in which the disease has been communicated otherwise than by inoculation.

18 Whether the cow-pox and small-pox ought to be considered as different diseases.

The writers upon this subject are divided in opinion, whether the cow-pox and small-pox ought to be considered as different diseases, or whether they are merely varieties of the same disease.

They certainly, notwithstanding the strong analogy which subsists between them, differ from each other in several striking particulars. The cow-pox comes to man from the cow, and is capable of being carried back from him to that animal. Similar attempts with variolous matter have failed: in this respect, then, these two morbid poisons are altogether different.

The local tumor produced by the inoculation of the cow-pox is commonly of a different appearance from that which is the consequence of inoculation with variolous matter: for if the inoculation of the cow-pox be performed by a simple puncture, the consequent tumor, in the proportion of three times out of four, according to Dr Woodville, assumes a form completely circular, and it continues circumscribed, with its edges elevated and well defined, and its surface flat, through every stage of the disease; while that which is produced from the variolous matter, either preserves a peculiar form, or spreads along the skin, and becomes angulated, or irregular, or disfigured by numerous vesiculæ. Another distinction still more decisive and general, is to be drawn from the contents of the cow-pox tumor; for the fluid here formed very rarely becomes puriform; and the scab which succeeds is of a harder texture, exhibits a smoother surface, and differs in its colour from that which is formed by the concretion of pus. The appearances, however, are sometimes so changed, that they can in no respect be distinguished from those which arise from the inoculation of small-pox. We may also mention that the tendency of the sore in the inoculated part to degenerate into a phagedenic ulcer does not occur in small-pox.

On the other hand, the points in which these two diseases resemble each other are very remarkable. When introduced into the body by inoculation, they affect the constitution in nearly the same length of time, and seem to be governed by nearly the same laws. They mutually destroy the susceptibility of the body for the action of each other.

Dr Pearson, who thinks the diseases ought to be considered as distinct species, nevertheless draws the following conclusions, as established by experience.

"That in certain constitutions, or under the circumstances of certain co-operating agents, *the vaccine poison produces a disease resembling the small-pox*; and of course the pustule in the inoculated part is *very different from that of the vaccine pox ordinarily occurring*, and the eruptions *resemble very much, if not exactly, some varieties of the small-pox*: That in some instances these eruptions have occurred, although the inoculated part exhibited the genuine vaccine pustule: That the matter of such eruptive cases, whether taken from the inoculated part, or from other parts, produces universally (A), or at least generally, similar eruptive cases; and has not (he believes) been seen to go back, by passing through different constitutions, to the state in which it produces what is called the *genuine vaccine disease*: That eruptions, of a different appearance from variolous ones, sometimes occur in the true cow-pox."

From these facts we are strongly inclined to think that the vaccine disease and the small-pox ought merely to be considered as varieties of the same disease; and we have little doubt that they both derive their origin from the same source. 19 They are probably only varieties of the same disease.

If Dr Jenner's opinion, that the vaccine disease is derived from *the grease*, were fully established, we should be disposed to offer a conjecture, that the *small-pox*, in coming from the horse to man, may have passed thro' some

(A) We have seen that Dr Woodville's table contains a few exceptions to this rule, though it strongly confirms the general truth of the proposition.

ſome animal different from the cow. and may thus have undergone a modification ſimilar to, but not exactly, the ſame with what takes place in the paſſage of the virus through the conſtitution of the cow.

But without having recourſe to this conjecture, which is perfectly gratuitous, we are of opinion that the variations which have taken place in the cow-pox within the laſt three years are ſufficient to warrant a belief, that the ſmall-pox may have originally been exactly the ſame diſeaſe, even in the human conſtitution, as the cow-pox is now; but that in a ſucceſſion of ages, and from the operation of cauſes wholly unknown to us, it may have been changed to what we now ſee it.

We ſhall now conclude this article with a few practical remarks, which we hope may be of uſe to practitioners who mean to begin the vaccine inoculation.

20 Practical remarks.

It is of the utmoſt conſequence that the matter employed ſhould be the genuine vaccine virus. Dr Jenner points out the following particulars as ſources of a ſpurious cow-pox: 1. That ariſing from puſtules on the nipples or udder of the cow, which puſtules contain no ſpecific virus. 2. From matter, although originally poſſeſſing the ſpecific virus, which has ſuffered a decompoſition, either from putrefaction, or any other cauſe leſs obvious to the ſenſes. 3. From matter taken from an ulcer in an advanced ſtage, though the ulcer aroſe from a true cow-pox. 4. From matter produced on the human ſkin from the contact of ſome peculiar morbid matter generated by a horſe.

Many have remarked that inoculation with the vaccine matter is more apt to fail in communicating the infection than with variolous matter, eſpecially if it be ſuffered to dry upon the lancet before it is uſed. This does not ſeem to depend upon the virus of the former being more volatile, but upon its becoming more hard and indiſſoluble upon exſiccation. Care ſhould therefore be taken to moiſten it a conſiderable time before it is uſed.

We have already noticed the danger that may ariſe from miſtaking the local effects of the vaccine diſeaſe for its effects upon the conſtitution. To guard practitioners againſt this error, Dr Woodville makes the following remarks: "When a conſiderable tumor and an extenſive redneſs take place at the inoculated part, within two or three days after the infectious matter has been applied, the failure of inoculation may be conſidered as certain as where neither redneſs nor tumor is the conſequence. This rapid and premature advancement of the inflammation will always be ſufficient to prevent the inoculator from miſtaking ſuch caſes for thoſe of efficient inoculation. But there are other circumſtances under which I have found the inoculation to be equally ineffectual, and which, as being more likely to deceive the inoculator, require his utmoſt circumſpection and diſcrimination. I here allude to caſes in which it happens that though the local affection does not exhibit much more inflammation than is uſual, yet neither veſicle nor puſtule ſupervenes; and in which, about the ſixth or ſeventh day, it rapidly advances into an irregular ſuppuration, producing a feſtering or cruſtaceous ſore. Care, however, ſhould be taken to diſtinguiſh this caſe from that in which the inoculated part aſſumes a puſtular form, though it continues for one or two days only, when the ſame appearances follow as thoſe above deſcribed; for I have experienced the latter inoculation to be as effectual as where the tumor has proceeded in the moſt regular manner."

"The effloreſcence at the inoculated part, which ſeldom intervenes before the eighth, or later than the eleventh, day, is to be regarded as an indication that the whole ſyſtem is affected; and if the patient has not felt any indiſpoſition on or before its approach, he may be aſſured that there will not be any afterwards. When effloreſcence does not commence till the eleventh day, it is almoſt always attended with more indiſpoſition than when it occurs on the eighth or ninth day. The efflorescence is more frequent in young infants than in children advanced to three or four years of age; and the former have the efflorescence and the diſeaſe more favourably than the latter, inſomuch that by far the greater part of them have no perceptible illneſs, and require no medicines. On the other hand, in adults, the cow-pox frequently produces headache, pain of the limbs, and other febrile ſymptoms, for two or three days, which are greatly relieved by a briſk purgative."

We would, upon the whole, recommend the vaccine inoculation to our medical readers as being an effectual preventative againſt the ſmall pox, and ſafer to the individual, while it is more advantageous to the public at large, in being leſs capable of propagation by contagion.

VECTOR, or Radius Vector, in aſtronomy, is a line ſuppoſed to be drawn from any planet, moving round a centre, or the focus of an ellipſe, to that centre or focus. It is ſo called, becauſe it is that line by which the planet ſeems to be carried round its centre; and with which it deſcribes areas proportional to the times.

VEGETABLES. } See *Vegetable Substances* in
VEGETATION. } this *Suppl.*

VENTILATION of Ships is a matter of ſo great importance, that we would rather hazard the ſtating of an idle project for this purpoſe, than omit any thing which may be uſeful. We hazard nothing, however, in ſtating the following plan by Mr Abernethy, who candidly acknowledges that it is built upon the principles which we, together with the learned editor of Chambers's Cyclopædia, have borrowed from Dr Hailes. This plan conſiſts merely in cauſing two tubes to deſcend from above the deck to the bottom of a veſſel, or as low as ventilation is required; and which ſhould communicate by ſmaller pipes (open at their extremities) with thoſe places deſigned to be ventilated. There ſhould be a contrivance for ſtopping theſe communicating pipes, ſo that ventilation may be occaſionally prevented from taking place, or confined to any particular part of the veſſel.

One of the principal air tubes ſhould deſcend as near to the ſtern of the veſſel as convenient, and the other as near to the ſtem.

Through that tube which is in the head, the foul air is to be extracted; and through that which is in the ſtern, the freſh air is to deſcend to the different decks and other apartments of the veſſel.

The extraction of the air is eaſily effected in the following manner: Let a tranſverſe tube be fitted to that which deſcends in the head of the veſſel; it may be ſunk within the level of the deck, ſo as to cauſe no inequality of ſurface. Let it be continued till it comes beneath

neath the fire-place, then afcend in a perpendicular direction through the fire, and open a little above it; or it may be made to communicate with the chimney. It would be more convenient if the fire was near the place where the tube rifes through the deck; but the experiment muft equally fucceed, if the tube be made to defcend again till it is beneath the common fire-place. The effect that will refult from this contrivance is obvious; when the tube which paffes through the fire is heated, the air will afcend with a force proportionable to its levity, and the afcending column can only be fupplied from below, confequently it muft come from all thofe parts of the fhip with which the main tube communicates.

When the ports are open, the quantity of air thus exhaufted from the fhip will be fupplied from all quarters; but if they were all fhut, and the hatchways and other openings completely clofed, the renewal of frefh air is made certain by means of the tube which defcends in the ftern. The main air tube, where it rifes above the deck in the ftern, fhould have an horizontal one fitted to it, which might be made to traverfe, fo that it could be turned to windward; it might alfo expand at its extremity like the mouth of a trumpet; and thus perfectly frefh air muft enter, and the force of the gale would tend to impel it into the veffel.

When that part of the tube which paffes through the fire is red hot, the draught which would be thus occafioned might perhaps be too great, and the open pipes which communicate with the decks might emit and imbibe the frefh air in fo direct a ftream, that it might be injurious to thofe perfons within the current.

Mr Abernethy therefore thinks it would be better if thofe fmaller pipes which lead from the main tubes were made to run along the decks, and communicate with them by numerous orifices. Two pipes opening into the main exhaufting tube might be extended along the tops of the deck, in the angle formed between the fides and the cieling: and thus the air would be extracted equally from all parts, and in a manner not likely to occafion injurious currents. Some divifion of the ftream of air which enters from the ftern might alfo be made, if it were thought neceffary.

Thus a very complete, and in no way injurious, ventilation may be obtained: the air in the veffel would be perfectly changed when the fire was ftrong, without expence or trouble; and a gradual and falubrious alteration of it might at all times be made, by a very little additional quantity of fuel. The air tubes fhould confift of feparate joints, fo that occafionally they might be taken to pieces; and to prevent their being injured or put out of order by rough ufage, the copper pipes fhould be made of confiderable ftrength, placed againft the fides of the veffel, and even incafed in wood.

In the Letters and Papers of the Bath Society, &c. we have the following defcription of a ventilator for preferving corn on fhip-board, by Thomas South, Efq;

Plate XLVII. Fig. 1. is a cylindrical air-veffel, or forcing pump, of lead, tin, or other cheap metal; its internal diameter being ten inches, and its length three feet; having a crutch-handled pifton to work with, and an iron nofle, *viz.* a hollow inverted cone, two feet long, to condenfe the air, and increafe its power in its paffage downwards. This cylinder fhould be rivetted or fcrewed, by means of an iron collar or ftraps, to the deck it paffes through, both above and below, as at *a a*; and fhould be farther fecured by fome holdfaft near *b*, to keep it fteady in working.

Fig. 2. is a bottom of wood, four inches and a half thick, with a projecting rim at its bafe, for the metal cylinder to reft on when cemented and fcrewed to the wood. The centre of this bottom is excavated, for the reception of the crown of the nofle. In the fame figure the nofle is reprefented with its crown like a bowl difh, to condenfe the air gradually, without refiftance, in its advance to the more contracted bafe of the inverted cone, *i. e.* the top or entrance of the nofle. About two-thirds down this nofle may be fixed a male fcrew, as *c c*, for the purpofe hereafter mentioned.

N. B. The forcing-pump fhould be cafed in wood, to protect it from outward bruifes, which would prevent the working of the pifton, and ruin its effects. The leather round the embolus fhould be greafed when ufed.

Fig. 3. is a crutch-handle, faftened to the embolus A by its iron legs B, B. A is a cylinder of wood, cafed with leather, fo as to fit well, but glide fmoothly, in the metal cylinder; having an opening as large as its ftrength will permit, for the free accefs of atmofpheric air. C is a valve well leathered on its top, and yielding downwards to the preffure of the air when the pifton is raifed up. D is a crofs bar of iron, to confine the valve, fo that it may clofe inftantly on the return of the pifton downwards.

Fig. 4. is a tin pipe or tube, of lefs than four inches diameter, and of fuch length as, when fixed to the bafe of the cylinder, fig. 1. fhall admit the nofle *d*, fig. 2. to within half an inch of the valve E, at the bottom of the wooden cylinder F, in fig. 4; which valve E will then yield to the preffure of air condenfed in its paffage through the nofle, and deliver it into the pipes below. This valve muft be well leathered on its upper furface, and faftened with an hinge of leather to the cylinder it is meant to clofe: affixed to its bottom is the fpindle G, paffing through a fpiral fpring H, which, being compreffed on the defcent of the valve, will, by its elafticity, caufe it to rife again, clofe the aperture above, and retain the air delivered beneath it. On connecting this cylinder with the upper end of the nofle, at *e e*, fig. 2. we muft carefully prevent any lapfe of air that way, by a bandage of oakum fmeared with wax, on which to fcrew the cylinder, like the joints of a flute air-tight. I is a bar of iron, having a rifing in its centre, wide enough for the fpindle to play through but at the fame time fufficiently contracted to prevent the paffage of the fpiral fpring.

Fig. 5. is an affemblage of tin pipes, of any lengths, fhaped fuitably and conveniently to their fituation in the fhip. to the form of which, when fhut into one another, they muft be adapted; obferving only, that the neck be ftraight for a length fufficient to admit the lower end of the cylinder, fig. 4. as high as the letter F, or higher.

Fig. 6. To the middle pipe, which runs along the bottom, fhould be fixed a perpendicular one, fully perforated, to convey the air more readily into the centre of the heap; and this may have a conical top, as reprefented in the Plate, perforated with a fmaller punch to prevent the air from efcaping too haftily. In large cargoes, two or three of thefe perpendiculars may be neceffary;

necessary; and each should be well secured by an iron bar *g*, screwed down to prevent their being injured by the shifting of the cargo in stormy weather or a rolling sea. The top of the conical cap of these pipes may reach two-thirds up the cargo.

Fig. 7. is a valve of the same construction as that represented in fig. 4. but inclosed in a tube of brass, having a female screw at *ff*, adapted to the male screw *cc*, on the nosle fig 2. and may then be inserted into the head of the pipe fig. 5. This will add to the expence; but in a large apparatus is to be preferred, as a more certain security from lapse of air, than the junction of the tube fig. 4. to the neck *ee* in fig. 2.

N. B. *ee* is a neck of wood, making a part of the bottom fig. 2. whereon to secure the tube fig. 4. when applied to the nosle. The joints of the pipes, when put together for use, should be made air-tight, by means of bees wax or some stronger cement, till they reach the bottom of the vessel, when there is no farther need of this precaution. The horizontal pipes should run by the side of the kelson the whole length of the hold. The tin plates of which K is made, should be punched in holes, like the rose of a watering-pot, in two or three lines only at most, and then formed into a tube, with the rough side outwards. L may have four or five lines of the like perforations. M, and the rest, should gradually increase in their number as they advance towards the middle of the hold, and continue fully perforated to the last pipe, which should be closed at its end to prevent the ingress of the corn. It is the centre of the cargo which most requires ventilating, yet air should pervade the whole. Like the trade winds, it will direct its course to the part most heated, and, having effected its salutary purpose there, will disperse itself to refresh the mass.

Where the hatches are close-caulked, to prevent the influx of water, vent-holes may be bored in convenient parts of the deck, to be bunged up, and opened occasionally, from whence the state of the corn may be known by the effluvia which ascend when the ventilator is working.

The power of the ventilator is determined by the square of its diameter multiplied into the length of the stroke, and that again by the number of strokes in any given time.

The air-vessel or forcing pump, with the rest of the apparatus here described, is adapted to a vessel of 120 tons burden; but by lengthening the air-vessel, extending its diameter to 14 inches, and adding 10 inches more to the length of the stroke, a power may be obtained of ventilating a cargo of 400 tons within the hour. If this machine be properly wrought for one hour every day, or even every two days, beginning the operations immediately when the corn is put on board, the cargo may be preserved from taint or injury of every kind during the longest voyage.

VERDEN, a duchy of Germany, in the circle of Lower Saxony. It is bounded on the east and south by that of Lunenburg; on the west, by the Weser and the duchy of Bremen; and on the north, by the duchies of Bremen and Lunenburg; extending both in length and breadth about 28 miles. It consists chiefly of heaths and high dry lands; but there are good marshes on the rivers Weser and Aller. In 1712, the Danes wrested this duchy from Sweden, and, in 1715, ceded it to the king of Great Britain, as elector of Hanover; which cession, in 1718, was confirmed by the Swedes. The inhabitants are Lutherans.

VERDIGRIS, or Acetite of Copper. See that article, *Encycl.* where an account is given of the process by which verdigris was long manufactured. A different, and more economical process, however, has for some years been practised in Montpellier, which is worthy of notice, because it may be adopted in this country by substituting the husks of gooseberries or currants for those of grapes

In the manufacture of verdigris, the materials are copper and the husks of grapes after the last pressing. The copper is formed into round plates, half a line in thickness, and from twenty to twenty five inches in diameter. Each plate, at Montpellier, is divided into twenty-five laminæ, forming almost all oblong squares of from four to six inches in length, three in breadth, and weighing about four ounces. They are beat separately with the hammer on an anvil to smooth their surfaces, and to give the copper the necessary consistence. Without this precaution it would exfoliate, and it would be more difficult to scrape the surface in order to detach the oxydated crust. Besides this, scales of pure metal would be taken off, which would hasten the consumption of the copper.

The husks, which should not be too much pressed, are first made to ferment by being put into close vats, and the fermentation is generally completed in three or four days. The time, however, must vary according to the temperature in which they are kept, and other circumstances. Whilst the husks are fermenting, a preliminary preparation is given to the copper plates. This consists in dissolving verdigris in water in an earthen vessel, and rubbing over each plate with a piece of coarse linen dipped in this solution. The plates are then immediately placed close to each other, and left in that manner to dry. Sometimes the plates are only laid on the top of the fermented husks, or placed under those which have been already used for causing the copper to oxydate. It has been observed, that when this operation has not been employed, the plates grow black at the first operation, instead of becoming green. It is not, however, necessary to those which have been once used, and are to be used again.

When the plates are thus prepared, and the husks have been brought to ferment, the workmen try whether the latter are proper for the process, by placing under them a plate of copper, and leaving it buried there for twenty-four hours. If the plate, after this period, is found covered with a smooth green crust, in such a manner that none of the metal appears, they are then thought fit for being disposed in layers with the copper. On the other hand, if drops of water are observed on the surface of the plates, the plates are said to *sweat*, and it is concluded that the heat of the husks has not sufficiently subsided. They consequently defer making another trial till the next day. When they are assured that the husks are in a proper state, they form them into layers in the following manner:

The plates are all put into a box, which, instead of having a bottom, is divided in the middle by a wooden grate. The plates disposed on this grate are so strongly heated by a chaffing-dish placed under them, that the woman employed in this labour is sometimes obliged

to

to take them up with a cloth, in order that ſhe may not burn her hands. As ſoon as they have acquired that heat, they are put into jars in layers with the huſks. Each jar is then cloſed with a covering of ſtraw, and left to oxydate. Thirty or forty pounds of copper, more or leſs according to the thickneſs of the plates, are put into each jar. At the end of ten, twelve, fifteen, or twenty days, the jar is opened; and if the huſks are white, it is time to take out the plates. The cryſtals are then ſeen detached, and of a ſilky appearance on their ſurface. The huſks are thrown back, and the plates are put in what is called *relai*. For that purpoſe they are immediately depoſited in a corner of the cellar on ſticks ranged on the floor. They are placed in an upright poſition, one leaning againſt the other; and at the end of two or three days they are moiſtened, by taking them up in handfuls and immerſing them in water in earthen pans. They are depoſited quite wet in their former poſition, and left there for ſeven or eight days; after which they are once or twice immerſed again. This immerſion and drying are renewed ſix or eight times every ſeven or eight days. As the plates were formerly put into wine, theſe immerſions were called *one wine*, *two wines*, *three wines*, according to the number of times. By this proceſs the plates ſwell up, the green is nouriſhed, and a coat of verdigris is formed on all their ſurfaces, which may be eaſily detached by ſcraping them with a knife.

This verdigris, which is called *freſh* verdigris, *moiſt* verdigris, is ſold by the manufacturers to people who dry it for foreign exportation. In this firſt ſtate it is only a paſte, which is carefully pounded in large wooden troughs, and then put into bags of white leather, a foot in height and ten inches in diameter. Theſe bags are expoſed to the air or the ſun, and are left in that ſtate till the verdigris has acquired the proper degree of dryneſs. By this operation it decreaſes about 50 *per cent.* more or leſs according to its primitive ſtate. It is ſaid to ſtand proof by the knife, when the point of that inſtrument puſhed againſt a cake of verdigris through the ſkin cannot penetrate it. White lead may be made by a ſimilar proceſs.

Cryſtallized VERDIGRIS is manufactured at Montpellier in the following manner: A vinegar, prepared by the diſtillation of ſour wine, is put into a kettle, and boiled on the common verdigris. After ſaturation the ſolution is left to clarify, and then poured into another kettle of copper, where it is evaporated till a pellicle forms on the ſurface. Sticks are then immerſed into it, and by means of ſome packthread are tied to ſome wooden bars that reſt on the edge of the kettle. Theſe ſticks are about a foot long, and are ſplit croſs-wiſe nearly two inches at the end, ſo that they open into four branches, kept at about the diſtance of an inch from each other by ſmall bags. The cryſtals adhere to theſe ſticks and cover them entirely, forming themſelves into groups or cluſters, of a dark blue colour, and a rhomboidal ſhape. Each cluſter weighs from five to ſix pounds. Three pounds of moiſt verdigris are required for one pound of the cryſtals; the undiſſolved reſiduum is thrown away.

VERDUN, an ancient, ſtrong, and conſiderable town of France, in the department of Meuſe, and late province of Lorrain, with a biſhop's ſee, and a ſtrong citadel. Its fortifications were conſtructed by the Chevalier de Ville and Marſhal de Vauban. The latter was a native of this place. In 175[illegible], great part of the cathedral was deſtroyed by lightning. Verdun was taken by the Pruſſians in 1792, but retaken by the French ſoon after. The inhabitants are noted for the fine ſweetmeats they make. It is ſeated on the river Maeſe, which runs through the middle, 42 miles ſouth-weſt of Luxemburg, and 150 eaſt of Paris E. Lon. 5° 28′ N. Lat. 45° 9.

VERMIFUGE, a medicine which expels worms from the inteſtines. Of theſe medicines numbers are daily advertiſed in the newſpapers as infallible, though the ingredients of which they are compoſed are carefully kept ſecret. We think it our duty therefore to aſſure our readers, that the medicines vended by quacks are generally the very ſame that would be preſcribed by a regular phyſician for the diſeaſe in which they are pretended to be ſpecifics, with this only difference, that the unſeen and unprincipled quack generally preſcribes them in more powerful doſes than the regular phyſician deems ſafe for his patient. Thus Ching's famous worm medicine, which has been ſo ſtrenuouſly recommended, is nothing more than mercury given in the very ſame form in which it is given by every phyſician; but Ching gives it in doſes, which, though they have not injured the children of a biſhop and a judge, we have *known* to *ſalivate* other children to the great hazard of their lives. It is indeed wonderful that parents ſhould truſt the health and the lives of their children to men whom they never ſaw, and whom they know to be not oppreſſed with an over delicate ſenſe of honour, in preference to a man of ſcience who has a character to ſupport, and who is probably their friend, and almoſt always their acquaintance.

Of the different vermifuges, however, it muſt be confeſſed that the greater number are liable occaſionally to fail. One of the moſt powerful which we have mentioned in the article MEDICINE, *Encycl.* is compoſed of the ſpiculæ of the *cowhage* or *cow-itch*; and ſince that article was publiſhed, it has come more into uſe, chiefly through the recommendation of Mr Chamberlaine ſurgeon. He ſays that a tea-ſpoonful of the electuary (See MEDICINE, *Encycl.* p. 342.) may be ſafely given to a young child, and one or even two table ſpoonfuls to adults. The medicine is to be taken in the morning faſting; and the doſe to be repeated for two or three mornings, after which a gentle purge completes the cure. This medicine, however, Mr Chamberlaine prohibits in every caſe where there is a tendency to inflammation in any part of the inteſtinal canal, or where the mucus has been carried off or greatly diminiſhed by dyſentery or any other cauſe.

Dr Haemmerlin of Ulm has lately recommended as a very powerful and ſafe vermifuge the coraline of Corſica, and ſays that it has been ſo uſed in that iſland with complete ſucceſs from time immemorial. It is a fucus adhering to the rocks waſhed by the ſea, and ſometimes to the ſtones and ſhells thrown upon the ſhore. It is found in little tufts. It is generally of a yellow colour, with a reddiſh tincture. When dried, as it appears when offered for ſale, it contains a ſtrong ſmell of the ſea. It conſiſts of little cartilaginous ſtalks, with full threads, gradually cylindrical and tubulated. Its taſte is ſalt and unpleaſant. In the ſyſtem of plants of Linnæus, it belongs to the claſs *cryptogamia*. Its moſt common

mon names are, fea-rock mofs; the Grecian herb; lemithochorton; and the coraline of Corfica. It is the *conferva helminthortos* of Schwendimann, and the *fucus helminthocorton* of Latourette. There is reafon to think that all thofe fpecies of fucus whofe texture is foft and fpungy, might be applied to the fame medicinal ufes. There is a fort of red coraline found in Sweden which, according to fome writers, is a greater deftroyer of worms than any other known fubftance; being not too ftrong for the ftomach either of infants or of adults. Schwendimann afferts that the *conferva dichotoma* of Linnæus, which is found in the ditches in England, bears a ftrong analogy to the coraline of Corfica. Might not this conferva be tried as a vermifuge? The Corfican coraline is in great eftimation in the pharmacopœias of the Continent, efpecially in that of Geneva, in which is given a recipe for preparing a fyrup of it.

VERMONT, one of the United States of North America, bounded on the north by Canada; on the eaft, by the river Connecticut, which divides it from New Hampfhire; on the fouth, by Maffachufets; and on the weft, by New York. It is about 155 miles long, and 60 broad, and is divided into 7 counties. A chain of high mountains, running north and fouth, divides this ftate nearly in the centre, between the river Connecticut and lake Champlain. The height of land is generally from 20 to 30 miles from the river, and about the fame diftance from the New York line. The natural growth upon this mountain is hemlock, pine, fpruce, and other evergreens: hence it has always a green appearance, and, on this account, has obtained the defcriptive name of Vermont, from the French *Verd Mont*, Green Mountain. On fome high parts of this mountain, fnow lies till May, and fometimes till July. The country is generally hilly, but not rocky. It is finely watered, the foil is very fertile, and there is not a better climate in the world. The inhabitants have very lately been eftimated at 100,000. The bulk of them are emigrants from Connecticut and Maffachufets. The principal town is Bennington, but the affembly generally hold their feffions at Windfor.

VESPA (See *Encycl.*). A new fpecies of this genus of infects has been lately defcribed by *Cuvier*, in a note read before the Philomathic Society of Paris. It has fome refemblance to the *vefpa nidulans* of Fabricius, which, as is generally known, is a native of certain parts of America. The nefts of the vefpa nidulans are conftructed of a very fine web, of a very folid and pretty white pafte. Their form is that of a bell clofed upon all fides, excepting a narrow hole at the bottom; and they are fufpended from the branches of trees.

The *vefpa* defcribed by Cuvier, which is a native of Cayenne in America, has in general more volume than the preceding fpecies, and its pafte is grey, coarfer, lefs homogeneous, and lefs folid. The bottom of its neft alfo, in lieu of being fhaped funnel-like, is flat, and the orifice appears at one of the fides of the bottom part, and not in the middle. In the country where it is found, this fpecies of wafp is called the *tatou fly* (*mouche tatou*). It differs greatly in form from that which Fabricius has defcribed; it is all entirely of a fhining black; the firft articulation, or joint of its abdomen, is narrow, and in form of a pear; the fecond, larger than the others, is in form of a bell: the wings are brown. The following is the character affigned to it by Cuvier:

Vefpatatua, Nigra, Nitida, Alis fufcis, abdomine pedicellato.

VESPERTILIO (fee *Encycl.*) has been fubjected to fome cruel, but curious experiments, by the Abbé Spallanzani and M. de Jurine. The former of thefe philofophers having let loofe feveral bats in a chamber perfectly dark, found that they flew about in it without any impediment, neither rufhing againft any thing in the apartment, nor touching the walls with their wings. This furprifed him; but imagining that they were conducted by fome glimpfe of light which he did not perceive, he blindfolded them with a fmall and very clofe hood. They then ceafed to fly; but he obferved, at the fame time, that this did not proceed from any deprivation of light, but rather from the conftraint thence occafioned, efpecially when a hood of a very light texture was attended with the fame effect.

He then conceived the idea of pafting up the eyes of the bats with a few drops of fize or gum; but they ftill flew about in the fame manner as if their eyes had been open. As this, however, was not fufficient, he pafted up the eyes of thefe animals with round bits of leather; and this even did not impede them in their flight.

That he might at length be certain of his object, he blinded them entirely, either by burning the cornea with a red hot wire, or by pulling out the pupil with a pair of fmall pincers, and fcooping out the eye entirely. Not contented even with this precaution, he covered the wounds with pieces of leather, that the light might have no influence whatever on the remains of the organs which had been deftroyed. The animals feemed to fuffer very much by this cruel operation; but when they were compelled to ufe their wings, either by day or by night, and even in an apartment totally dark, they flew perfectly well, and with great caution, towards the walls, in order to fufpend themfelves when they wifhed to reft. They avoided every impediment, great or fmall, and flew from one apartment to another, backwards and forwards, through the door by which they were connected, without touching the frame with their wings. In a word, they fhewed themfelves as bold and lively in their flight as any other animals of the fame fpecies which enjoy the ufe of their eye-fight.

Thefe experiments were repeated by M. Jurine, and with the fame refults. Spallanzani had fuppofed that the bat poffeffed fome organ or fenfe which is wanting in the human fpecies, and which fupplies to thefe animals the place of vifion; and Jurine determined to afcertain the truth or falfehood of this hypothefis by anatomical refearches. During the courfe of thefe, he found the organ of hearing very great in proportion to that of other animals, and a confiderable nervous apparatus affigned to that part. The upper jaw alfo is furnifhed with very large nerves, which are expanded in a tiffue on the muzzle.

M. Jurine then extended his experiments to the organ of hearing and that of fmell. Having put a fmall hood on a long-eared bat, it immediately pulled it off, and flew. He ftopped up its ears with cotton; but it freed itfelf in the like manner from that inconvenience. He then put into its ears a maftic of turpentine and wax. During the operation the animal fhewed a great deal of impatience, and flew afterwards very imperfectly.

A long-eared bat, the ears of which had been bound up, flew very badly: but this did not arife from any pain

pain occasioned by the ligature; for when its ears were sewed up, it flew exceedingly well. In all probability the animal would have preferred having its ears bound up to having them sewed. Sometimes it flew towards the cieling, extending its muzzle before it settled.

M. Jurine poured liquid pomatum into the ears of a bat which enjoyed the use of its sight. It appeared to be much affected by this operation; but when the substance was removed it took flight. Its ears were again filled, and its eyes were taken out; but it flew then only in an irregular manner, without any certain or fixed direction.

The ears of a horse-shoe bat, which had the use of its sight, were filled with tinder mixed with water. It was uneasy under the operation, and appeared afterwards restless and stunned; but it conducted itself tolerably well. On being blinded, it rushed with its head against the cieling, and made the air resound with strokes which it gave itself on the muzzle. This experiment was repeated on other bats with the like effects.

The tympanum of a large horse-shoe bat was pierced with a pin (*trois quart*). The animal appeared to suffer much from the operation, and fell down in a perpendicular direction when thrown into the air. It died next morning. The same effect was produced on piercing the tympanum of a long-eared bat with a needle.

The author then made very accurate researches on the difference between the organisation of the brain of these two kinds of bats; and, after a careful dissection, found that the eye of the long-eared bat is much larger than that of the horse-shoe bat, but that the optic nerve is proportioned to it. The outer part of the ear of the former is much larger than that of the latter, but the interior part is smaller.

The horse-shoe bat is indemnified for this difference by a greater extension of the organ of smell, as evidently appears when the external elevations and irregularities of its muzzle are examined. When it is about to take flight, it agitates its nose much more than the long-eared bat.

From these experiments, the author concludes: *First*, That the eyes of the bat are not indispensably necessary to it for finding its way; *secondly*, That the organ of hearing appears to supply that of sight in the discovery of bodies, and to furnish these animals with different sensations to direct their flight, and enable them to avoid those obstacles which may present themselves.

VIBRATION Figures, are certain figures, formed by sand or very dry saw-dust, on a vibrating surface, which is connected with the sensation of sound in our organs of hearing. If the surface, on which the figures are to be formed, be strewed over with bodies easily put in motion, these, during the vibration, remain on the parts at rest, and are thrown from the parts in motion. The form of the parts at rest, which will be shewn by the sand that remains unmoved, and which, in general, is symmetric, is called a *vibration figure*. To produce such a figure, nothing is necessary but to know the method of bringing that part of the surface which you wish not to vibrate into a state of rest, and of putting in motion that which you wish to vibrate. On this depends the whole expertness of producing vibration figures.

Thus take a square piece of glass, pretty thin, and very smooth, such as that used for windows, about four or five inches over, or even more. Smooth it at the edges on a grinding-stone; strew a little saw-dust over its surface, and lay hold of it gently with the thumb and forefinger of the left hand. Holding it thus by the middle, with the right hand rub a violin bow softly against one of its edges, drawing the bow either up or down in a direction almost perpendicular to the surface of the glass, and you will see a tremulous movement, and the whole dust leap about. If the bow be exactly in the middle of one of the sides, the dust will arrange itself almost in the direction of the two diagonals, dividing the square into four isosceles triangles. If the bow be applied at a quarter only of the distance of the one corner from the other, the dust will arrange itself in such a manner as to be found in the two diameters of the square, dividing it into four equal squares. At other times, when the bow diviates a little, the dust forms a figure like a double C, when the two letters are joined back to back. If the square be held by the two extremities of the diameter, opposite to that against which the bow is applied, the dust will form a kind of oval, one of the axes of which will be the same diameter. If the glass be of a circular figure, and be held by the middle, the dust will arrange itself in such a manner as to form the six radii of a regular hexagon. These discoveries were made by Dr Chladni, about the time that he invented the musical instrument, to which he gave the name of EUPHON (see that article, *Suppl.*); and as he found the vibration figures to vary in form with the various tones produced by the vibrating substances, a prosecution of his experiments may probably contribute to throw new light on the philosophy of musical sounds. We shall therefore give, from the 3d volume of *Neues Journal der Physik*, by professor Gren, a few directions for making such experiments.

Any sort of glass may be employed, provided its surface be smooth; and when the plate has acquired the proper vibration, it should be kept in that state for some seconds, by continuing to rub it with the bow. The figures will thus be accurately formed.

Such plates should be procured as are pretty equal in thickness. It may be said, in general, that a plate the thinner it is will be so much the fitter for these experiments, though in this respect there is a certain minimum. In small plates, such as those that are circular, and not above six inches in diameter, the observation is general; but in larger plates too great thinness is prejudicial. Besides, it will be found that very thin glass is commonly very uneven, and must therefore be unfit for the experiments.

In practising the experiments, it will be proper to have plates of different sizes; and the sand employed should not be too fine. In other words, it must be of such a nature that when you incline the glass-plate it may readily roll off; because, in that case, it will be easily thrown from the vibrating parts. It will be of advantage that it be mixed with fine dust, which shews peculiar phenomena during the experiments, as it collects itself at one place of the vibrating part.

The plate must be equally bestrewed with sand, and not too thick, as the lines will then be exceedingly fine, and the figures will acquire a better defined appearance.

VIETA (Francis), a very celebrated French mathematician, was born in 1540 at Fontenai, or Fontenai-le-Comté, in Lower Poitou, a province of France. He

Hutton's Mathematical Dictionary.

Vieta.

He was Master of requests at Paris, where he died in 1603, being the 63d year of his age. Among other branches of learning in which he excelled, he was one of the most respectable mathematicians of the 16th century, or indeed of any age. His writings abound with marks of great originality, and the finest genius, as well as intense application. His application was such, that he has sometimes remained in his study for three days together without eating or sleeping. His inventions and improvements in all parts of the mathematics were very considerable. He was in a manner the inventor and introducer of Specious Algebra, in which letters are used instead of numbers, as well as of many beautiful theorems in that science. He made also considerable improvements in geometry and trigonometry. His angular sections are a very ingenious and masterly performance: by these he was enabled to resolve the problem of Adrian Romanus, proposed to all mathematicians, amounting to an equation of the 45th degree. Romanus was so struck with his sagacity, that he immediately quitted his residence of Wirtzbourg in Franconia, and came to France to visit him, and solicit his friendship. His Apollonius Gallus, being a restoration of Apollonius's tract on Tangencies, and many other geometrical pieces to be found in his works, shew the finest taste and genius for true geometrical speculations.—He gave some masterly tracts on Trigonometry, both plane and spherical, which may be found in the collection of his works, published at Leyden in 1646, by Schooten, besides another large and separate volume in folio, published in the author's life-time, at Paris, in 1579, containing extensive trigonometrical tables, with the construction and use of the same, which are particularly described in the introduction to Dr Hutton's Logarithms, p. 4. &c. To this complete treatise on trigonometry, plane and spherical, are subjoined several miscellaneous problems and observations; such as, the quadrature of the circle, the duplication of the cube, &c. Computations are here given of the ratio of the diameter of a circle to the circumference, and of the length of the sine of 1 minute, both to a great many places of figures; by which he found that the sine of 1 minute is

between 2908881959
and 2908882056;

also the diameter of a circle being 1000, &c. that the perimeter of the inscribed and circumscribed polygon of 393216 sides will be as follows, viz. the

perim. of the inscribed polygon - 31415926535
perim. of the circumscribed polygon 31415926537

and that therefore the circumference of the circle lies between those two numbers.

Vieta having observed that there were many faults in the Gregorian Kalendar, as it then existed, composed a new form of it, to which he added perpetual canons, and an explication of it, with remarks and objections against Clavius, whom he accused of having deformed the true Lelian reformation, by not rightly understanding it.

Besides these, it seems a work, greatly esteemed, and the loss of which cannot be sufficiently deplored, was his *Harmonicon Cœleste*, which, being communicated to father Mersenne, was, by some perfidious acquaintance of that honest-minded person, surreptitiously taken from him and irrecoverably lost, or suppressed, to the great detriment of the learned world. There were also, it is said, other works of an astronomical kind, that have been buried in the ruins of time.

Vintain || Vision

Vieta was also a profound decipherer, an accomplishment that proved very useful to his country. As the different parts of the Spanish monarchy lay very distant from one another, when they had occasion to communicate any secret designs, they wrote them in ciphers and unknown characters during the disorders of the league. The cipher was composed of more than 500 different characters, which yielded their hidden contents to the penetrating genius of Vieta alone. His skill so disconcerted the Spanish councils for two years, that they published it at Rome, and other parts of Europe, that the French king had only discovered their ciphers by means of magic.

VINTAIN, a town, situated about two miles up a creek on the southern side of the river Gambia. It is much resorted to by Europeans, on account of the great quantities of bees-wax which are brought hither for sale. The wax is collected in the woods by the Feloops, a wild and unsociable race of people. Their country, which is of considerable extent, abounds in rice; and the natives supply the traders, both on the Gambia and Cassamansa rivers, with that article, and also with goats and poultry, on very reasonable terms. The honey which they collect is chiefly used by themselves in making a strong intoxicating liquor, much the same as the mead which is produced from honey in Great Britain.

In their traffic with Europeans, the Feloops generally employ a factor, or agent, of the Mandingo nation, who speaks a little English, and is acquainted with the trade of the river. This broker makes the bargain; and, with the connivance of the European, receives a certain part only of the payment; which he gives to his employer as the whole; the remainder (which is very truly called the *cheating money*) he receives when the Feloop is gone, and appropriates to himself as a reward for his trouble. Vintain, according to Mr Park, from whose valuable travels this account of the Feloops is taken, is situated in 13° 9′ North Lat. and 15° 56′ Long. West from Greenwich.

VIRGINITY, the test or criterion of a virgin; or that which intitles her to the denomination. See HYMEN, *Encycl.*

VISION. In the article OPTICS, n° 154. (*Encycl.*), it is said, that as we have a power of contracting or relaxing the *ligamenta ciliaria*, and thereby altering the form of the crystalline humour of the eye, we hence see objects distinctly at different distances. It appears, however, from some experiments made by Mr Everard Home and Mr Ramsden, in the year 1794, that this power of contracting and relaxing the ligamenta ciliaria is not alone sufficient to account for the phenomenon. Conversing with Mr Home on the different uses of the chrystalline humour, Mr Ramsden said, that as that humour "consists of a substance of different densities, the central parts being the most compact, and from thence diminishing in density gradually in every direction, approaching the vitreous humour on one side, and the aqueous humour on the other, its refractive power becomes nearly the same with that of the two contiguous substances. That some philosophers have stated the use of the crystalline humour to be, for accommodating

commodating the eye to see objects at different distances: but the firmness of the central part, and the very small difference between its refractive power near the circumference and that of the vitreous or the aqueous humour, seemed to render it unfit for that purpose; its principal use rather appearing to be for correcting the aberration arising from the spherical figure of the cornea, where the principal part of the refraction takes place, producing the same effect that, in an achromatic object-glass, we obtain in a less perfect manner by proportioning the radii of curvature of the different lenses. In the eye the correction seems perfect, which in the object-glass can only be an approximation; the contrary aberrations of the lenses not having the same ratio: so that, if this aberration be perfectly corrected, at any given distance from the centre, in every other it must be in some degree imperfect.

"Pursuing the same comparison: In the achromatic object glass we may conceive how much an object must appear fainter from the great quantity of light lost by reflection at the surfaces of the different lenses, there being as many primary reflections as there are surfaces; and it would be fortunate if this reflected light was totally lost. Part of it is again reflected towards the eye by the interior surfaces of the lenses; which, by diluting the image formed in the focus of the object-glass, makes that image appear far less bright than it would otherwise have done, producing that milky appearance so often complained of in viewing lucid objects through this sort of telescope.

"In the eye, the same properties that obviate this defect, serve also to correct the errors from the spherical figure, by a regular diminution of density, from the centre of the crystalline outward. Every appearance shews the crystalline to consist of laminæ of different densities; and if we examine the junction of different media, having a very small difference of refraction, we shall find that we may have a sensible refraction without reflection. Now, if the difference between the contiguous media in the eye, or the laminæ in the crystalline, be very small, we shall have refraction without having reflection: and this appears to be the state of the eye; for although we have two surfaces of the aqueous, two of the crystalline, and two of the vitreous humour, yet we have only one reflected image; and that being from the anterior surface of the cornea, there can be no surface to reflect it back, and dilute an image on the retina.

"This hypothesis may be put to the test whenever accident shall furnish us with a subject having the crystalline extracted from one eye, the other remaining perfect in its natural state; at the same time we may ascertain whether or no the crystalline is that part of the organ which serves for viewing objects at different distances distinctly. Seeing no reflection at the surface of the crystalline, might lead some persons to infer that its refractive power is very inconsiderable; but many circumstances shew the contrary: yet what it really is may be readily ascertained by having the focal length and distance of a lens from the operated eye, that enables it to see objects the most distinctly; also the focal length of a lens, and its distance from the perfect eye, that enables it to see objects at the same distance as the imperfect eye: these data will be sufficient whereby to calculate the refractive power of the crystalline with considerable precision.

"Again, having the spherical aberration of the different humours of the eye, and having ascertained the refractive power of the crystalline, we have data from whence to determine the proportional increase of its density as it approaches the central part, on a supposition that this property corrects the aberration.

"An opportunity presented itself for bringing the observations of Mr Ramsden, respecting the use of the crystalline lens, to the proof. A young man came into St George's Hospital with a cataract in the right eye. The crystalline lens was readily extracted, and the union of the wound in the cornea took place unattended by inflammation; so that the eye suffered the smallest degree of injury that can attend so severe an operation. The man himself was in health, 21 years of age, intelligent, and his left eye perfect: the other had been an uncommonly short time in a diseased state, and 27 days after the operation appeared to be free from every other defect but the loss of the crystalline lens.

"A number of experiments were made on the imperfect eye, assisted by a lens, and compared with the perfect eye. The aim of these trials, which were judiciously varied, was to ascertain whether the eye which had been deprived of the crystalline lens was capable of adjusting itself to distinct vision at different distances. Among other results, the perfect eye, with a glass of $6\frac{1}{2}$ inches focus, had distinct vision at 3 inches; the near limit was $1\frac{7}{8}$ inch, the distant limit less than 7 inches. The imperfect eye, with a glass $2\frac{2}{10}$ inches focus, with an aperture $\frac{1}{10}$ths of an inch, had distinct vision at $2\frac{7}{8}$ inches, the near limit $1\frac{7}{8}$ inch, and the distant limit 7 inches. The accuracy with which the eye was brought to the same point, on repeating the experiment, proved it to be uncommonly correct; and as he did not himself see the scale used for admeasurement, there could be no source of fallacy. From the result of this experiment, it appears that the range of adjustment of the imperfect eye, when the two eyes were made to see at nearly the same focal distance, exceeded that of the perfect eye. Mr Ramsden suggested a reason why the point of distinct vision of the imperfect eye might appear to the man himself nearer than it was in reality; namely, that from the imperfection of this organ he might find it easier to read the letters when they subtended a greater angle than at his real point of distinct vision. The experiments, however, appear to shew that the internal power of the eye, by which it is adjusted to see at different distances, does not reside in the crystalline lens, at least not altogether; and that if any agency in this respect can be proved to reside in the crystalline, the other powers, whatever they may be, are capable of exertion beyond their usual limits, so as to perform its office in this respect.

"From these considerations, and in consequence of other reflections tending to shew that an elongation of the optical axis is not probably the means of adjustment, these philosophers directed their enquiries to ascertain how far the curvature of the cornea might be subject to change. They found by trial that this part of the organ possesses a degree of elasticity which is very considerable, both for its perfection and its range; and by anatomical

anatomical diffection it was found that the four ftraight mufcles of the eye do in effect terminate in the cornea at their tendinous extremities; that the whole external lamina of the cornea could by gentle force be feparated, by means of thefe mufcles, from the eye; fo that the tendons feem loft in the cornea, and this laft has the appearance of a central tendon. It was alfo feen that the central part of the cornea is the thickeft and the moft elaftic.

"Thefe were confiderable advances towards eftablifhing the hypothefis of adjuftment by the external curve of the eye. It remained to be fhewn, by experiments on the living fubject, that this curve does really vary in the due direction, when the mind perceives the diftinct vifible fenfation of objects at different diftances. For this purpofe Mr Ramfden provided an apparatus, confifting of a thick board fteadily fixed, in which was a fquare hole large enough to admit a perfon's face; the forehead and chin refting againft the upper and lower bars, and the cheek againft either of the fides; fo that when the face was protruded, the head was fteadily fixed by refting on three fides; and in this pofition the left eye projected beyond the outer furface of the board. A microfcope, properly mounted, fo as with eafe to be fet in every requifite pofition, was applied to view the cornea with a magnifying power of thirty times. In this fituation, the perfon whofe eye was the object of experiment was defired to look at the corner of a chimney, at the diftance of 235 yards, through a fmall hole in a brafs plate, fixed for that purpofe, and afterwards to look at the edge of the hole itfelf, which was only fix inches diftant. After fome management and caution, which the delicate nature of thefe experiments requires, the motion of the cornea, which was immediately perceptible, became very diftinct and certain. The circular fection of its furface remained in a line with the wire in the field of the microfcope, when the eye was adjufted to the diftant object, but projected confiderably beyond it when adapted to the near one. When the diftant object was only 90 feet from the obferver, and the near object fix inches, the difference in the prominence of the cornea was eftimated at 1-800th of an inch. Thefe experiments were repeated and varied at different times and on different fubjects. The obferver at the microfcope found no difficulty in determining, from the appearance of the cornea, whether the eye was fixed on the remote or the near object.

"From thefe different experiments Mr Home confiders the following facts to have been afcertained:

"1. That the eye has a power of adjufting itfelf to different diftances when deprived of the cryftalline lens; and therefore the fibrous and laminated ftructure of that lens is not intended to alter its form, but to prevent reflections in the paffage of the rays through the furfaces of media of different denfities, and to correct fpherical aberration.

"2 That the cornea is made up of laminæ; that it is elaftic, and when ftretched is capable of being elongated 1-11th part of its diameter, contracting to its former length immediately upon being left to itfelf.

"3. That the tendons of the four ftraight mufcles of the eye are continued on to the edge of the cornea, and terminate, or are inferted, in its external laminæ: their action will therefore extend to the edge of the cornea.

"4. That in changing the focus of the eye from feeing with parallel rays to a near diftance, there is a vifible alteration produced in the figure of the cornea, rendering it more convex; and when the eye is again adapted to parallel rays, the alteration by which the cornea is brought back to its former ftate is equally vifible."

Mr Home made many other experiments with a view to throw light upon this curious fubject; and the refult of the whole appears to be, that the adjuftment of the eye is produced by three different changes in that organ; an increafe of curvature in the cornea, an elongation of the axis of vifion, and a motion of the cryftalline lens. Thefe changes, in a great meafure, depend upon the contraction of the four ftraight mufcles of the eye. Mr Ramfden, from computations grounded on the principles of optics and general ftate of the facts, eftimates that the increafe of curvature of the cornea may be capable of producing one-third of the effect, and that the change of place of the lens, and elongation of the axis of vifion, fufficiently account for the other two-thirds of the quantity of adjuftment neceffary to make up the whole.

VITALITY, the power of fubfifting in life, which the fafhionable philofophers of the French and German fchools attribute to *chemiftry*. For a confutation of their abfurd and impious jargon on this fubject, we refer our readers, with fome degree of confidence, to the articles PHYSIOLOGY (*Encycl.*), and *Animal* SUBSTANCES (*Suppl.*)

VIVERRA (fee *Encycl.*) A new fpecies of this genus of animals was difcovered by Vaillant during his laft travels in Africa; at leaft he ranks under the generic name *Viverra*, the animal of which he gives the following defcription. Its body was of the fize of that of a kitten fix months old: it had a very large nofe, the upper jaw exceeding the lower near two-thirds of an inch in length, and forming a fort of moveable fnout refembling that of the *coati* of Guiana. The fore feet were armed with four large claws, very fharp and curved; the hind ones have each five, but they are fhort and blunt. All the fur on the upper part of the body is marked with crofs bands of a deep brown colour, on a ground of light brown with which many white hairs are intermixed. The lower part of the body and infides of the legs are of a reddifh white. The tail, which is very flefhy, and more than two thirds longer than the body, is black at the tip, and the reft brown, intermixed with white hairs.

This animal employs its fore paws to dig very deep holes in the earth, in which it remains concealed during the day, not going out till fun-fet in queft of food.

The Hottentots who accompanied our traveller called it *muys-hond* (a moufe dog); a general name among the inhabitants of the Cape for all the fmaller carnivorous quadrupeds.

VIVES (Ludovicus), the contemporary and friend of Erafmus, was a native of Valentia in Spain. Though well trained in all the fubtleties of the fcholaftic philofophy at Paris, he had the good fenfe to difcover its futility, and diligently applied himfelf to more ufeful ftudies. At Louvain he undertook the office of a preceptor, and exerted himfelf with great ability and fuccefs in correcting barbarifm, chaftifing the corrupters of learning, and reviving a tafte for true fcience and elegant letters. Erafmus, with whom he lived upon the

Vives, Ultramarine.

footing of intimate friendſhip, ſpeaking of Vives when he was only 26 years of age, ſays, that there was no part of philoſophy in which he did not excel; and that he had made ſuch proficiency in learning, and in the arts of ſpeaking and writing, that he ſcarcely knew his equal. He wrote a commentary upon Auguſtine's treatiſe *De Civitate Dei*, which diſcovers an extenſive acquaintance with ancient philoſophy. Henry VIII. of England, to whom he dedicated this work, was ſo pleaſed with it, that he invited the author to his court, and made him preceptor to his daughter Mary. Though he diſcharged his office with great fidelity, yet in conſequence of his oppoſition to the king's divorce, he fell under his diſpleaſure; and it was not without difficulty that he eſcaped to Bruges, where he devoted the remainder of his days to ſtudy. He died in the year 1537, or, according to Thuanus, in 1541. With Eraſmus and Buddæus he formed a triumvirate of literature which did honour to the age. He wrote *De Prima Philoſophia*, "On the Firſt Philoſophy;" *De Explanatione Eſſentiarum*, "On the Explanation of Eſſences;" *De Cenſura Veri*, "On the Teſt of Truth;" *De Initiis, Sectis, et Laudibus Philoſophiæ*, "On the Origin, Sects, and Praiſes of Philoſophy;" and *De Corruptis Artibus et Tradendis Diſciplinis*, "On the Corruption of Science, and on Education." Theſe writings, of which the two laſt are the moſt valuable, diſcover great ſtrength of judgment, an extenſive knowledge of philoſophy, much enlargement of conception, uncommon ſagacity in detecting the errors of ancient and modern philoſophers, particularly of Ariſtotle and his followers, and, in fine, a mind capable of attempting things beyond the ſtandard of the age in which he lived. To all this he added great perſpicuity and elegance of ſtyle, not unworthy of the friend of Eraſmus.

ULTRAMARINE is a very fine blue powder, almoſt of the colour of the corn-flower or blue-bottle, which has this uncommon property, that, when expoſed to the air or a moderate heat, it neither fades nor becomes tarniſhed. On this account it is uſed in painting; but it was employed formerly for that purpoſe much more than at preſent, as ſmalt, a far cheaper article, was not then known. (See COBALT, in this *Suppl.*) Ultramarine is made of the blue parts of the lapis lazuli, by ſeparating them as much as poſſible from the other coloured particles with which they are mixed, and reducing them to a fine powder. The real lapis lazuli is found in the mountains of that part of Tartary called Bucharia, which extends eaſtwards from the Caſpian ſea, and particularly at Kalab and Budukſchu. It is ſent thence to the Eaſt Indies, and from the Eaſt Indies to Europe. Good ultramarine muſt be of a beautiful dark colour, and free from ſand as well as every other mixture. It muſt unite readily with oil; it muſt not become tarniſhed on a red-hot tile or plate of iron, and it ought to diſſolve in ſtrong acids, almoſt like the zeolite, without cauſing an efferveſcence. In the year 1763, an ounce of it at Paris coſt four pounds ſterling, and an ounce of *cendre d'outremer*, which is the refuſe, two pounds. The baſis of this colour was long ſuſpected to be copper, but the experiments of Margraff ſhewed that it was iron, in ſome unknown ſtate of combination. New light has been thrown on this ſubject by Morveau, who has diſcovered that ſelenite loaded with iron, when decompoſed by carbonaceous matter, yields a blue ſulphuret of iron of equal permanency with the true ultramarine.

Unicorn, Vortices.

At preſent, ſmalt of a good colour is often purchaſed at a dear rate and ſubſtituted for ultramarine: and it is found that the colour of this preparation of cobalt is more durable in the fire than even that of the lapis lazuli. For the analyſis of lapis lazuli, ſee MINERALOGY, n° 69. *Suppl.*

UNICORN, the ſcriptural name of an animal, which was undoubtedly the one horned rhinoceros. Ariſtotle, however, deſcribes a unicorn of a different kind; and, from his deſcription, ſeems to have been derived the idea of that figure, which is one of the ſupporters of the royal arms of Great Britain, and is generally ſuppoſed to repreſent a fictitious animal, or creature of the imagination. But this ſuppoſition, if not groundleſs, ſeems to be carried by much too far. Under the word UNICORN (*Encycl.*) we have recorded the teſtimony of Sparman and Labo, to the exiſtence of a unicorn ſhaped like a beautiful horſe; and their teſtimony has lately been ſtrongly corroborated by Mr Barrow, (A) a man of unqueſtionable veracity, who held a high office under government when the Cape of Good Hope was in the poſſeſſion of the Engliſh. He actually ſaw figures of the unicorn, ſuch as deſcribed by Labo, drawn with thoſe of the elephants and other animals on the ſmooth rocks in the interior of the country; and he very naturally infers that ſuch figures would not have been conceived by ſavages, who had not ſeen the living animal. The Boſhmen or Bojeſmans, were ſurpriſed at his expreſſing any doubt of its exiſtence; and the Dutch coloniſts take it for granted that ſuch an animal is to be found beyond the limits of the colony. Some of the Bojeſmans ſeemed ready to undertake an expedition to the north ſide of the great range of mountains, and for a proper reward to bring to the author a real unicorn; but what prevented the expedition we are not told. It may be performed, and is ſurely as well worthy of the amateurs of natural hiſtory as a journey into the heart of Africa in queſt of birds, flowers, or ſerpents. Till very lately the MAMMOTH (ſee *Encycl.*) was confounded with the elephant, and ſtrange inferences were thence drawn reſpecting the change of the poles of the earth. But now (1802) the ſkeleton of a *Mammoth* is exhibiting in London, whence it appears that the two animals, though nearly the ſame ſize, are quite diſtinct, and that the one may have lived in countries, where the bones of the mammoth are indeed generally found, of ſuch a temperature, that the elephant could not exiſt in them five months. Now, indeed, the mammoth ſeems to be extinct, and ſo may the unicorn be; but it appears unqueſtionable that both have once exiſted; and it is probable that the latter ſtill exiſts.

VORTICES of Des Cartes are now juſtly exploded; but being the fiction of a very ſuperior mind, they are ſtill an object of curioſity, as being the foundation of a great philoſophical romance. According to the author of that romance, the whole of infinite ſpace was full

(A) See his *Travels into the Interior of Southern Africa, in the years* 1797, 1798.

Vortices. full of matter; for with him matter and extenfion were the fame, and confequently there could be no void. This immenfity of matter he fuppofed to be divided into an infinite number of very fmall cubes; all of which, being whirled about upon their own centres, neceffarily gave occafion to the production of two different elements. The firft confifted of thofe angular parts which, having been neceffarily rubbed off, and grinded yet fmaller by their mutual friction, conftituted the moft fubtle and moveable part of matter. The fecond confifted of thofe little globules that were formed by the rubbing off of the firft. The interftices betwixt thefe globules of the fecond element were filled up by the particles of the firft. But in the infinite collifions, which muft occur in an infinite fpace filled with matter, and all in motion, it muft neceffarily happen that many of the globules of the fecond element fhould be broken and grinded down into the firft. The quantity of the firft element having thus been increafed beyond what was fufficient to fill up the interftices of the fecond, it muft, in many places, have been heaped up together, without any mixture of the fecond along with it. Such, according to Des Cartes, was the original divifion of matter. Upon this infinitude of matter thus divided a certain quantity of motion was originally impreffed by the Creator of all things, and the laws of motion were fo adjufted as always to preferve the fame quantity in it, without increafe, and without diminution. Whatever motion was loft by one part of matter, was communicated to fome other; and whatever was acquired by one part of matter, was derived from fome other: and thus, through an eternal revolution from reft to motion, and from motion to reft, in every part of the univerfe, the quantity of motion in the whole was always the fame.

But as there was no void, no one part of matter could be moved without thrufting fome other out of its place, nor that without thrufting fome other, and fo on. To avoid, therefore, an infinite progrefs, he fuppofed that the matter which any body pufhed before it rolled immediately backwards to fupply the place of that matter which flowed in behind it; as we may obferve in the fwimming of a fifh, that the water which it pufhes before it immediately rolls backwards to fupply the place of what flows in behind it, and thus forms a fmall circle or vortex round the body of the fifh. It was in the fame manner that the motion originally impreffed by the Creator upon the infinitude of matter neceffarily produced in it an infinity of greater and fmaller vortices, or circular ftreams: and the law of motion being fo adjufted as always to preferve the fame quantity of motion in the univerfe, thofe vortices either continued for ever, or by their diffolution gave birth to others of the fame kind. There was thus at all times an infinite number of greater and fmaller vortices, or circular ftreams, revolving in the univerfe.

But whatever moves in a circle is conftantly endeavouring to fly off from the centre of its revolution. For the natural motion of all bodies is in a ftraight line. All the particles of matter therefore, in each of thofe greater vortices, were continually preffing from the centre to the circumference, with more or lefs force, according to the different degrees of their bulk and folidity. The larger and more folid globules of the fecond element forced themfelves upwards to the circumference, while the fmaller, more yielding, and more active particles of the firft, which could flow even through the interftices of the fecond, were forced downwards to the centre. They were forced downwards to the centre notwithftanding their natural tendency was upwards to the circumference; for the fame reafon that a piece of wood, when plunged in water, is forced upwards to the furface, notwithftanding its natural tendency is downwards to the bottom; becaufe its tendency downwards is lefs ftrong than that of the particles of water, which, therefore, if one may fay fo, prefs in before it, and thus force it upwards. But there being a greater quantity of the firft element than what was neceffary to fill up the interftices of the fecond, it was neceffarily accumulated in the centre of each of thefe great circular ftreams, and formed there the fiery and active fubftance of the fun. For, according to that philofopher, the folar fyftems were infinite in number, each fixed ftar being the centre of one; and he is among the firft of the moderns who thus took away the boundaries of the univerfe: even Copernicus and Kepler, themfelves, have confined it within what they fuppofed the vault of the firmament.

The centre of each vortex being thus occupied by the moft active and moveable parts of matter, there was neceffarily among them a more violent agitation than in any other part of the vortex, and this violent agitation of the centre cherifhed and fupported the movement of the whole. But among the particles of the firft element, which fill up the interftices of the fecond, there are many, which, from the preffure of the globules on all fides of them, neceffarily receive an angular form, and thus conftitute a third element of particles lefs fit for motion than thofe of the other two. As the particles, however, of this third element were formed in the interftices of the fecond, they are neceffarily fmaller than thofe of the fecond, and are therefore, along with thofe of the firft, urged down towards the centre, where, when a number of them happen to take hold of one another, they form fuch fpots upon the furface of the accumulated particles of the firft element, as are often difcovered by telefcopes upon the face of that fun which enlightens and animates our particular fyftem. Thofe fpots are often broken and difpelled by the violent agitation of the particles of the firft element, as has hitherto happily been the cafe with thofe which have fucceffively been formed upon the face of our fun. Sometimes, however, they encruft the whole furface of that fire which is accumulated in the centre; and the communication betwixt the moft active and the moft inert parts of the vortex being thus interrupted, the rapidity of its motion immediately begins to languifh, and can no longer defend it from being fwallowed up and carried away by the fuperior violence of fome other like circular ftream; and, in this manner, what was once a fun becomes a planet. Thus the time was, according to the fyftem, when the moon was a body of the fame kind with the fun, the fiery centre of a circular ftream of ether, which flowed continually round her; but her face having been crufted over by a congeries of angular particles, the motion of this circular ftream began to languifh, and could no longer defend itfelf from being abforbed by the more violent vortex of the earth, which was then, too, a fun, and which chanced to be placed in its neighbourhood. The moon therefore became a planet, and revolved round the earth. In procefs of time,

time, the fame fortune, which had thus befallen the moon, befel alfo the earth; its face was encrufted by a grofs and inactive fubftance; the motion of its vortex began to languifh, and it was abforbed by the greater vortex of the fun: but though the vortex of the earth had thus become languid, it ftill had force enough to occafion both the diurnal revolution of the earth, and the monthly motion of the moon. For a fmall circular ftream may eafily be conceived as flowing round the body of the earth, at the fame time that it is carried along by that great ocean of ether which is continually revolving round the fun; in the fame manner as, in a great whirpool of water, one may often fee feveral fmall whirpools, which revolve round centres of their own, and at the fame time are carried round the centre of the great one. Such was the caufe of the original formation and confequent motions of the planetary fyftem. When a folid body is turned round its centre, thofe parts of it which are neareft, and thofe which are remoteft from the centre, complete their revolutions in one and the fame time. But it is otherwife with the revolutions of a fluid: the parts of it which are neareft the centre complete their revolutions in a fhorter time than thofe which are remoter. The planets, therefore, all floating in that immenfe tide of æther which is continually fetting in from weft to eaft round the body of the fun, complete their revolutions in a longer or a fhorter time, according to their nearnefs or diftance from him.

This bold fyftem was eminently fitted to captivate the imagination; and though fraught with contradictions and impoffibilities, attempts have been made to revive it, even in this country, under different names. All thofe fyftems which reprefent the motions of the heavenly bodies as being the effect of the phyfical agency of æthers, of air, of fire, and of light, of which the univerfe is conceived to be full, labour under the fame difficulties with the Cartefian hypothefis; and very few of them, if any, are fo neatly put together. It is furely fufficient, however, to demolifh this goodly fabric, barely to afk how an abfolute infinity of matter can be divided into cubes, or any thing elfe? how there can poffibly be interftices in a perfect plenum? or how in fuch a plenum any portion of matter can be thruft from its place?

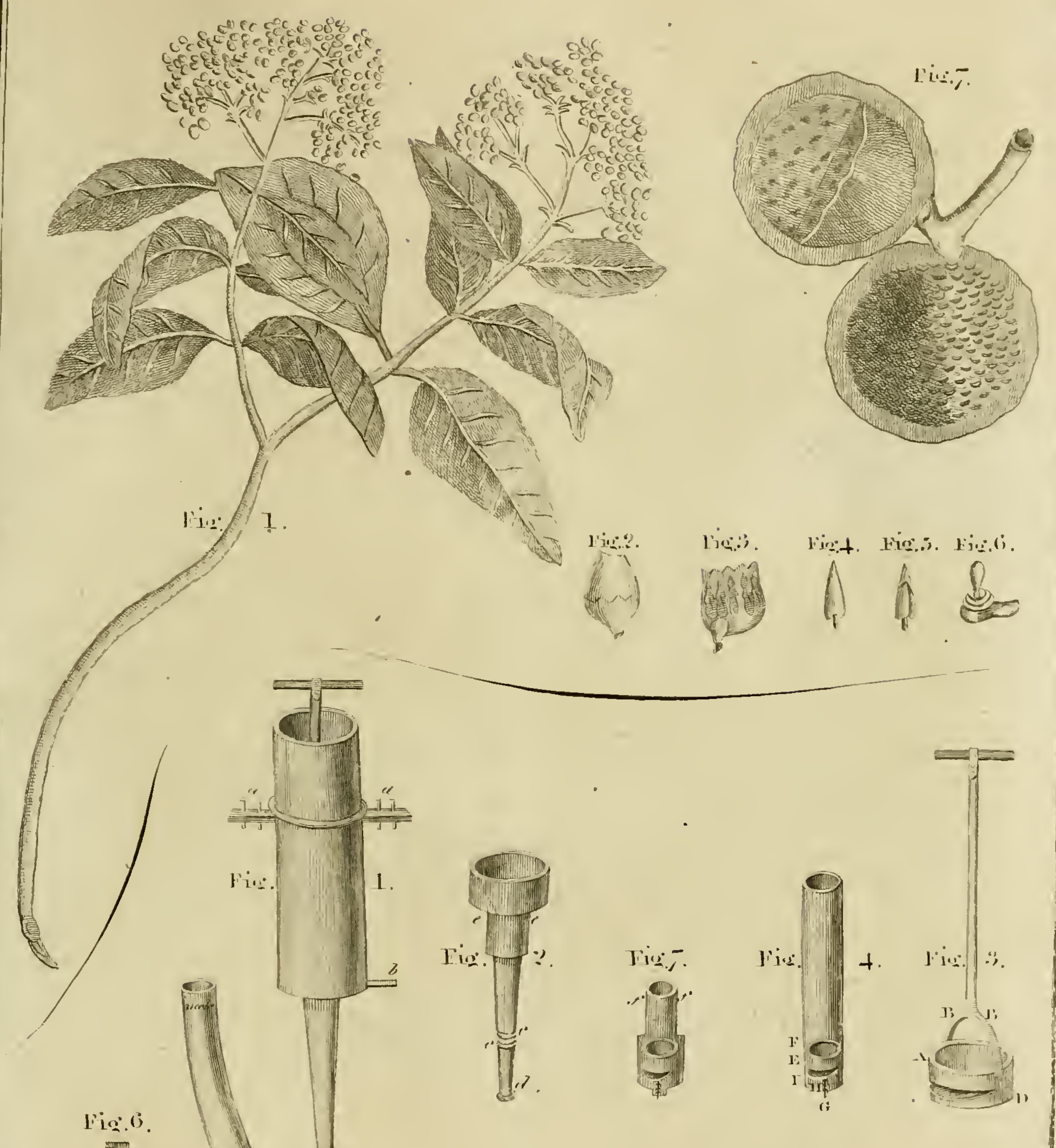
URALIAN Cossacs, a people that inhabit the Ruffian province of Orenburg in Afia, on the fouth fide of the river Ural. Thefe Coffacs are defcended from thofe of the Don: they are a very valiant race. They profefs the Greek religion; but there is a kind of diffenters from the eftablifhed religion, whom the Ruffians called *Rofkolniki*, or Separatifts, and who ftyle themfelves *Staroverfki*, or Old Believers. They confider the fervice of the eftablifhed church as profane and facrilegious, and have their own priefts and ceremonies. The Uralian Coffacs are all enthufiafts for the ancient ritual, and prize their beards almoft equal to their lives. A Ruffian officer having ordered a number of Coffac recruits to be publicly fhaved in the town of Yaitfk, in 1771, this wanton infult excited an infurrection, which was fuppreffed for a time; but, in 1773, that daring impoftor, Pugatchef, having affumed the name and perfon of Peter III. appeared among them, and taking advantage of this circumftance, and of their religious prejudices, roufed them once more into open rebellion. This being at laft effectually fuppreffed by the defeat and execution of the impoftor (See Suworow, *Suppl.*), in order to extinguifh all remembrance of this rebellion, the river Yaik was called *Ural*; the Yaik Coffacs were denominated *Uralian Coffacs*; and the town of Yaitfk, *Uralfk*. The Uralian Coffacs enjoy the right of fifhing on the coaft of the Cafpian Sea, for 47 miles on each fide of the river Ural. Their principal fifhery is for fturgeons and beluga, whofe roe fupplies large quantities of caviare; and the fifh, which are chiefly falted and dried, afford a confiderable article of confumption in the Ruffian empire. In confequence of thefe fifheries, thefe Coffacs are very rich.

URBINO, a town of Italy, in the territory of the Pope, and capital of the duchy of Urbino, with an old citadel, an archbifhop's fee, and a handfome palace, where the dukes formerly refided. The houfes are well built, and great quantities of fine earthen ware are made here. It is feated on a mountain, between the rivers Metro and Foglia, 18 miles fouth of Rimini, 58 eaft of Florence, and 120 north-eaft of Rome. E. Lon. 12. 40. N. lat. 43. 46.

Urbino, a duchy of Italy, in the territory of the church, bounded on the north by the gulph of Venice; on the fouth, by Perugino and Umbria; on the eaft, by the marquifate of Ancona; and on the weft, by Tufcany and Romagna. It is about 55 miles in length, and 45 in breadth. Here is great plenty of game and fifh; but the air is not very wholefome, nor is the foil fertile. Urbino is the capital.

URCEOLA, a lately difcovered genus of the *pentandria* clafs, and *monogynia* order of plants, ranking immediately after Tabernæ montana (fee *Encycl.*), and confequently belonging to the 30th natural order or clafs called *Contortæ* by Linnæus in his natural method of arrangement. One of the qualities of the plants of this order is their yielding, on being cut, a juice which is generally milky, and for the moft part deemed of a poifonous nature. The genus is thus characterifed by Dr Roxburgh: *Calyx* beneath five-toothed; corol one petaled, pitcher fhaped, with its contracted mouth five-toothed: nectary entire, furrounding the germs; follicles two, round, drupacious; feeds numerous, immerfed in pulp. There is but one known fpecies, which is thus defcribed by the fame eminent botanift;

Urceola elastica: Shrubby, twining, leaves oppofite, oblong, panicles terminal, is a native of Sumatra, Prince of Wales's Ifland, &c. Malay countries. *Stem* woody, climbing over trees, &c. to a very great extent, young fhoots twining, and a little hairy, bark of the old woody parts thick, dark coloured, confiderably uneven, a little fcabrous, on which are found feveral fpecies of mofs, particularly large patches of lichen; the wood is white, light, and porous. *Leaves* oppofite, fhort-petioled, horizontal, ovate, oblong, pointed, entire, a little fcabrous, with a few fcattered white hairs on the under fide. *Stipulus* none. *Panicles* terminal, brachiate, very ramus. *Flowers* numerous, minute, of a dull greenifh colour, and hairy on the outfide. *Bracts* lanceolate, one at each divifion and fubdivifion of the panicle. *Calyx* perianth, one-leaved, five-toothed, permanent. *Corol* one petaled, pitcher-fhaped, hairy, mouth much contracted, five-toothed, divifions erect, acute, nectary entire, cylindric, embracing the lower two-thirds of the germs. *Stamens*, filaments five, very fhort from the bafe of the corol. Anthers arrow-fhaped, converging,



D. Lizars sculp.

Urceola. verging, bearing their pollen in two grooves on the infide, near the apex; between thefe grooves and the infertions of the filaments they are covered with white foft hairs. *Piftil*, germs two; above the nectary they are very hairy round the margins of their truncated tops. Style fingle, fhorter than the ftamens. Stigma ovate, with a circular band, dividing it into two portions of different colours. *Per.* Follicles two, round, laterally compreffed into the fhape of a turnip, wrinkled, leathery, about three inches in their greateft diameters—one celled, two valved. *Seeds* very numerous, reniform, immerfed in firm flefhy pulp.

See Plate XLVII. where fig. 1. is a branchlet in flower of the natural fize. 2. A flower magnified. 3. The fame laid open, which expofes to view the fituation of the ftamens inferted into the bottom of the corol, the nectarium furrounding the lower half of the two germs, their upper half with hairy margins, the ftyle and ovate party coloured; ftigma appearing above the nectary. 4. Outfide of one of the ftamens; and, 5. Infide of the fame, both much magnified. 6. The nectarium laid open, expofing to view the whole of the piftil. 7. The two feed veffels (called by Linnæus *follicles*), natural fize; half of one of them is removed, to fhew the feed immerfed in pulp. A portion thereof is alfo cut away, which more clearly fhews the fituation and fhape of the feed.

From wounds made in the bark of this plant there oozes a milky fluid, which on expofure to the open air feparates into an elaftic coagulum, and watery liquid apparently of no ufe, after the feparation takes place. This coagulum is not only like the American caoutchouc or Indian rubber, but poffeffes the fame properties; for which, fee CAOUTCHOUC, both in the *Encycl.* and *Suppl.*

The chemical properties of this vegetable milk, while frefh, were found by Mr Howifon, late furgeon on Prince of Wales's Ifland, furprifingly to refemble thofe of animal milk. From its decompofition, in confequence of fpontaneous fermentation, or by the addition of acids, a feparation takes place between its cafeous and ferous parts, both of which are very fimilar to thofe produced by the fame proceffes from animal milk. An oily or butyrous matter is alfo one of its component parts, which appears upon the furface of the gum fo foon as the latter has attained its folid form. He endeavoured to form an extract of this milk fo as to approach to the confiftence of new butter, by which he hoped to retard its fermentative ftage, without depriving it of its ufeful qualities; but as he had no apparatus for diftilling, the furface of the milk, that was expofed to the air, inftantly formed into a folid coat, by which the evaporation was in a great degree prevented. He, however, learned, by collecting the thickened milk from the infide of the coats, and depofiting it in a jelly pot, that, if excluded from the air, it might be preferved in this ftate for a confiderable length of time; and even without any preparation be kept in bottles, tolerably good, upwards of twelve months.

Urinary, Urtica. URINARY, CONCRETIONS. See *Animal Substances*, Suppl.

URTICA. See *Encycl.* where it is obferved that the common nettle, though it has a place in the *materia medica*, is now very little ufed. It has lately been recommended, however, by *Zannetini*, a phyfician who attended the French army in Italy, as a good fubftitute in fevers for cinchona. The fuccefs of fome experiments, which he made with it in tertian and quartain malignant fevers, furpaffed, he fays, his moft fanguine expectation. The nettle often produces a fpeedier effect than bark; for it heats in a great degree, and when the dofe is pretty ftrong, occafions a lethargic fleep. The dofe muft never exceed a dram, and is given in wine two or three times in the courfe of 24 hours. Zannetini found this medicine of great fervice to guard againft that total exhauftion which forms the principal character of malignant fevers; and he recommends a flight infufion of it in wine as an excellent prefervative for thofe who refide in marfhy and infalubrious diftricts. In employing the nettle in fever, Zannetini gives the fame caution as ought to be obferved in regard to cinchona, that is, that it muft not be employed where there is an inclination to inflammation, or where a continued fever, arifing from obftructions, exifts. This difcovery is not unworthy the attention of phyficians, and deferves at leaft to be farther inveftigated, as a great deal would be faved if cinchona could be entirely difpenfed with.

W.

Wales. WALES, New South, is a country which muft be interefting on account of the fingular colony which was fettled there in the year 1788. Under the title *New Holland* (*Encycl.*) fome account has been given of that fettlement, as well as of the climate and the foil about Port Jackfon; but it will probably gratify the curiofity of our readers, if we give a fhort hiftory of thofe European fettlers, of whom it is to be hoped that they carried not with them, to that diftant fhore,

"Minds not to be changed by time or place."

This hiftory we fhall take from the accurate *Account of the Englifh Colony in New South Wales*, by David Collins, Efq; who went out with Governor Phillip, and continued to execute the offices of Judge-advocate and Secretary

Wales. Secretary till the close of the year 1796; and we shall begin our narrative from the disembarkation of the first colonists, when his Majesty's commission to the governor, and the letters patent, establishing courts of criminal and civil judicature in the territory, were read.

The criminal court was constituted a court of record, and was to consist of the judge-advocate and such six officers of the sea and land service as the governor shall, by precept issued under his hand and seal, require to assemble for that purpose This court has power to inquire of, hear, determine, and punish all treasons, misprisions of treasons, murders, felonies, forgeries, perjuries, trespasses, and other crimes whatsoever that may be committed in the colony; the punishment for such offences to be inflicted according to the laws of England as nearly as may be, considering and allowing for the circumstances and situation of the settlement and its inhabitants. The charge against any offender is to be reduced into writing, and exhibited by the judge-advocate: witnesses are to be examined upon oath, as well for as against the prisoner; and the court is to adjudge whether he is guilty or not guilty by the opinion of the major part of the court. If guilty, and the offence is capital, they are to pronounce judgment of death, in like manner as if the prisoner had been convicted by the verdict of a jury in England, or of such corporal punishment as the court, or of the major part of it, shall deem meet. And in cases not capital, they are to adjudge such corporal punishment as the majority of the court shall determine. But no offender is to suffer death unless five members of the court shall concur in adjudging him to be guilty, until the proceedings shall have been transmitted to England, and the king's pleasure signified thereupon. The provost-marshal is to cause the judgement of the court to be executed according to the governor's warrant under his hand and seal.

Beside this court for the trial of criminal offenders, there is a civil court, consisting of the judge-advocate and two inhabitants of the settlement, who are to be appointed by the governor; which court has full power to hear and determine in a summary way all pleas of lands, houses, debts, contracts, and all personal pleas whatsoever.

From this court, on either party, plaintiff or defendant, finding himself or themselves aggrieved by the judgment or decree, an appeal lies to the governor, and from him, where the debt or thing in demand shall exceed the value of L. 300, to the king in council.

A vice-admiralty court was also appointed, for the trial of offences on the high seas; and the governor, lieutenant-governor, and judge-advocate, were by patent made justices of the peace, with a power in the governor to appoint other justices.

The situation which Governor Phillip had selected for his residence, and for the principal settlement, was the east side of a cove in Port Jackson, which he called *Sydney Cove*. Its latitude was found to be 33° 52′ 30″ south, and its longitude 152° 19′ 30″ east. This situation was chosen without due examination; for it soon appeared that the head or upper part of the cove wore a much more favourable appearance than the ground immediately about the settlement. From the natives, the new settlers met no opposition: during the first six weeks they received only one visit from them, two men strolling one evening into the camp, and remaining in it for about half an hour. They appeared to admire whatever they saw; and after receiving a hatchet (of the use of which the eldest instantly and curiously shewed his knowledge, by turning up his foot and sharpening a piece of wood on the sole with the hatchet) took their leave, apparently well pleased with their reception. The fishing boats also frequently reported their having been visited by many of these people when hauling the seine; at which labour they often assisted with cheerfulness, and in return were generall rewarded with a part of the fish taken.

The first labour in which the convicts were employed was that of building huts; and for this purpose it was found necessary to divide them into gangs, and to appoint an overseer to each, who should see that the proper quantity of work was performed. The provisions were distributed by a weekly ration, and to each man were allowed 7lb. of biscuit, 1lb. of flour, 7lb. of beef or 4lb. of pork, 3 pints of pease, and 6 ounces of butter. To the female convicts two thirds of this ration were allowed. This was the full ration, which, in many instances, it became necessary to reduce; and once, in consequence of the delay of transports with a supply, the convicts were put on an allowance of which flesh meat constituted no part.

The temporary huts in which the colonists lived, for some time after their arrival, were formed principally of the cabbage-tree. With this the sides and ends were filled; the posts and plates being made of the pine; and the whole was plastered with clay. The roofs were generally thatched with the grass of the gumrush; though some were covered with clay; but several of these failed, the weight of the clay and rain soon destroying them. In a short time they applied themselves to the burning of bricks; by which their habitations soon became much more lasting and comfortable. The progress of the colony, however, towards that degree of convenience which was within its reach, was greatly impeded by the incorrigible vices of those who principally composed it. Drunkenness, theft, robbery, and unconquerable laziness, continued to mark the character of the great body of the convicts. Though to fly from the colony, and venture into the interior of the country, was inevitable death in the form of famine or of murder, yet such was the invincible antipathy to labour manifested by some of those people, that they often fled to the woods, from which they seldom returned; some dying of hunger, and some being sacrificed by the natives. Disinclination to labour produced here, as elsewhere, its natural effect—robbery.

In the month of May 1788, a lad of 17 years of age was tried, convicted, and executed, for breaking open a tent belonging to one of the transport ships; several others were taken into custody in that month for various thefts and burglaries, and two were afterward tried and executed. One of these had absconded, and lived in the woods for 19 days, subsisting by what he was able to procure by nocturnal depredations among the huts and stock of individuals. His visits for this purpose were so frequent and daring, that it became absolutely necessary to proclaim him an outlaw. By the negligence of one of those fellows who had been entrusted with the care of the cattle, the bull and four cows were lost: he left them in the fields, and returned to his hut to dine; and in the mean time they either strayed away or were

Wales. were driven off by the natives Five years elapfed before thefe cattle were difcovered wild, at a confiderable diftance up tbe country, and greatly multiplied.

The perpetration of crimes, chiefly theft and robbery, had become fo prevalent before twenty months had paffed fince the colony was eftablifhed, that it was neceffary to think of a fyftem of police. A plan was prefented to the governor by a *convict*, which with fome improvements was adopted on the 8th of Auguft 1789. The following are the heads of the arrangement.

The fettlement was divided into four diftricts, over each of which was placed a watch confifting of three perfons, one principal and two fubordinate watchmen. Thefe being felected from among thofe convicts whofe conduct and character had been unexceptionable fince their landing, were vefted with authority to patrole at all hours in the night, to vifit fuch places as might be deemed requifite for the difcovery of any felony, trefpafs or mifdemeanor, and to fecure for examination all perfons that might appear to be concerned therein; for which purpofe they were directed to enter any fufpected hut or dwelling, or to ufe any other means that might appear expedient. They were required to detain and give information to the neareft guardhoufe of any foldier or feaman who fhould be found ftraggling after the tattoo had been beat. They were to ufe their utmoft endeavours to trace out offenders on receiving accounts of any depredation; and in addition to their night-duty, they were directed to take cognizance of fuch convicts as gamed, or fold or bartered their flops or provifions, and report them for punifhment. A return of all occurrences during the night was to be made to the judge-advocate; and the military were required to furnifh the watch with any affiftance they might be in need of, beyond what the civil power could give them. They were provided each with a fhort ftaff, to diftinguifh them during the night, and to denote their office in the colony; and were inftructed not to receive any ftipulated encouragement or reward from any individual for the conviction of offenders, but to expect that negligence or mifconduct in the execution of their truft would be punifhed with the utmoft rigour. It was to have been wifhed, fays Mr Collins, that a watch eftablifhed for the prefervation of public and private property had been formed of free people, and that neceffity had not compelled us, in felecting the firft members of our little police, to appoint them from a body of men, in whofe eyes, it could not be denied, the property of individuals had never before been facred. But there was not any choice: The military had their line of duty marked out for them, and between them and the convict there was no defcription of people from whom overfeers or watchmen could be provided. It might, however, be fuppofed, that among the convicts there muft be many who would feel a pride in being diftinguifhed from their fellows, and a pride that might give birth to a returning principle of honefty. It was hoped that the convicts whom we had chofen were of this defcription; fome effort had become neceffary to detect the various offenders who were prowling about with fecurity under cover of the night; and the convicts who had any property were themfelves interefted in defeating fuch practices. They promifed fidelity and diligence, from which the fcorn of their fellow-prifoners fhould not induce them to fwerve, and began with a confidence of fuccefs the duty which they had themfelves offered to undertake.

A fpecies of difturber now infefted the colony, againft which the vigilance of a police could not guard. Rats, in immenfe numbers, had attacked the provifion ftores, and could be counteracted only by removing the provifions from one ftore to another. When their ravages were firft difcovered, it was found that eight cafks of flour were already deftroyed by thefe vermin. Such of thefe animals as efcaped the dogs, which were fet upon them, flew to the gardens of individuals, where they rioted on the Indian corn that was growing, and did confiderable mifchief.

Our author gives the moft melancholy account of the extreme fufferings of the early colonifts from want of provifions, and of the difeafes imported into the country by newcomers, who had either caught them on the voyage or brought them from England The fettlers on Norfolk-*Ifland* (fee *Encycl.*), to which New South Wales was a mother country, muft have been much more liable than that colony to fuffer from famine, had they not fometimes obtained a temporary fupply from a fource which was unknown at Sydney Cove. On a mountain in the ifland, to which had been given the name of *Mount Pitt*, they were fortunate enough to obtain, in an abundance almoft incredible, a fpecies of aquatic birds, anfwering the defcription of that known by the name of the *puffin*. Thefe birds came in from the fea every evening, in clouds literally darkening the air, and defcending on Mount Pitt, depofited their eggs in deep holes made by themfelves in the ground, generally quitting them in the morning, and returning to feek their fubfiftence in the fea. From two to three thoufand of thefe birds were often taken in a night. Their feeking their food in the ocean left no doubt of their own flefh partaking of the quality of that upon which they fed; but to people circumftanced as were the inhabitants on Norfolk Ifland, this leffened not their importance; and while any Mount Pitt birds (fuch being the name given them) were to be had, they were eagerly fought.

The firft fettler in New South Wales, who declared himfelf able to live on the produce of his farm, without any affiftance from the ftores, was James Rufe; who in April 1790 relinquifhed his claim to any farther fhare of the public provifion. As a reward, the governor immediately put him in poffeffion of an allotment of 30 acres

In the July of the fame year, the convicts whofe terms of tranfportation had expired were now collected, and by the authority of the governor informed, that fuch of them as wifhed to become fettlers in this country fhould receive every encouragement; that thofe who did not, were to labour for their provifions, ftipulating to work for 12 or 18 months certain; and that in the way of fuch as preferred returning to England no obftacles would be thrown, provided they could procure paffages from the mafters of fuch fhips as might arrive; but that they were not to expect any affiftance on the part of government to that end. The wifh to return to their friends appeared to be the prevailing idea, a few only giving in their names as fettlers, and none engaging to work for a certain time.

That the wifh to return home was ftrong indeed, and paramount to all other feelings, was evinced in a very

Wales.

melancholy inftance fome time before. A convict, an elderly man, was found dead in the woods, near the fettlement; who, on being opened, it appeared, had died from want of nourifhment; and it was found that he was accuftomed to deny himfelf even what was abfolutely neceffary to his exiftence, abftaining from his provifions, and felling them for money, which he was referving, and had fomewhere concealed, in order to purchafe his paffage to England when his time fhould terminate!

Of fome convicts whofe terms of tranfportation had expired, the governor eftablifhed a new fettlement in Auguft 1791, at a place which he called *Profpect Hill*, about twenty miles diftant from Sydney Cove; and another refidence was formed at the Ponds within three or four miles of the former. This made the fourth fettlement in the colony, exclufively of that at Norfolk Ifland.

About this time the governor received from England a public feal for the colony: on the obverfe of which were the king's arms and royal titles; and on the reverfe, emblematic figures fuited to the fituation of the people for whofe ufe it was defigned. The motto was "*Sic fortis Etruria crevit;*" and in the margin were the words "*Sigillum Nov. Camb. Auft.*" A commiffion alfo arrived, empowering him to remit abfolutely, or conditionally, the whole or any part of the term for which the felons fent to the colony might be tranfported. By this power he was enabled to beftow on fuperior honefty and induftry the moft valuable reward which, in fuch circumftances, they could receive.

In addition to the calamities under which the fettlement had fo often laboured from being reduced to very fhort allowance of provifions, and the frequency of the ordinary difeafes which were to be expected among a people fo fituated, a new malady of a very alarming nature was perceived about April 1792. Several convicts were feized with infanity; and as the major part of thofe who were vifited by this calamity were females, who, on account of their fex, were not haraffed with hard labour, and who in general fhared largely of fuch little comforts as were to be procured in the fettlement, it was difficult to affign a caufe for this diforder. It feems, however, to have been of fhort duration; for we hear not of it again during the period that Mr Collins's narrative comprehends.

About this time (1792) the colony had affumed fomething of an eftablifhed form. Brick huts were in hand for the convicts in room of the miferable hovels occupied by many, which had been put up at their firft landing, and in room of others which, from having been erected on fuch ground as was then cleared, were now found to interfere with the direction of the ftreets which the governor was laying out. People were alfo employed in cutting paling for fencing in their gardens. At a place called Paramatta, about 16 miles from Sydney Cove, fituated on a fmall river which runs into Port Jackfon, the people were employed, during the greateft part of the month of May, in getting in the maize and fowing wheat. A foundation for an hofpital was laid, a houfe built for the mafter carpenter, and roofs prepared for the different huts either building or to be built in future.

In December 1792, when Captain Phillip refigned the government, nearly five years from the foundation of the colony, there were in cultivation at the different fettlements 1429 acres, of which 417 belonged to fettlers; that is, 67 fettlers, for there was no more, cultivated nearly half as much ground as was cultivated by the public labour of all the convicts; a ftriking proof of the fuperior zeal and diligence with which men exert themfelves when they have an intereft in their labour. Of free fettlers, whofe exertions promifed fo fairly to promote the interefts of the colony, feveral arrived from England in January 1793, and fixed themfelves in a fituation which they called *Liberty Plains.* To one of thefe, Thomas Rofe, a farmer from Dorfetfhire, and his family of a wife and four children, 120 acres were allotted. The conditions under which thefe people agreed to fettle were, "to have their paffage provided by government (A); an affortment of tools and implements to be given to them out of the ftores; that they fhould be fupplied with two years provifions; that their lands fhould be granted free of expence; the fervice of convicts alfo to be affigned to them free of expence; and that thofe convicts fhould be fupplied with two years rations and one year's clothing."

Among the great difficulties with which this infant eftablifhment had to ftruggle, not the leaft was that of procuring cattle. Of thofe which were embarked in England and other places for the colony, a very fmall proportion only arrived; for of 15 bulls and 119 cows, which had been embarked for Botany Bay, only 3 bulls and 28 cows were landed at the fettlement. It was not until the arrival of the Endeavour, Captain Bampton, in 1795, that the mode of conveying cattle to the colony without material lofs was difcovered. In that veffel, out of 130 head which he embarked at Bombay, one cow only died on the paffage, and that too on the day before his arrival.

The fcarcity of cattle naturally raifed their price. Even after this laft importation, an Englifh cow in calf fold for L.80.

Notwithftanding the various obftacles which induftry had met in the cultivation of this fettlement, it yet made confiderable advances; for in October 1793, the value of land had fo rifen, that one fettler fold his allotment of 30 acres for as many pounds; and one farm, with the houfe, &c. fold for L.100. The value of ground, indeed, was confiderably enhanced by government agreeing to purchafe the redundance of the produce of the fettlers at fixed prices. Wheat properly dried and cleanfed was received from the fettlers at Sydney, by the commiffary, at 10s. per bufhel. Some cultivators, however, had devifed another mode of difpofing of their corn. One of them, whofe fituation was near Paramatta, having obtained a fmall ftill from England, found it more advantageous to draw an ardent diabolical fpirit from his wheat, than to fend it to the ftores. From one bufhel of wheat he obtained nearly five quarts of fpirit, which he fold or paid in exchange for labour, at the rate of five or fix fhillings per quart.

(A) Government paid for the paffage of each perfon above ten years of age L.8, 8s. and one fhilling per day for victualling them.

Wales.

quart. A better ufe was made of grain by another fettler; who, having a mill, ground it, and procured 44lb. of good flour, from a bufhel of wheat taken at 59lb. This flour he fold at 4d. per lb.

By a return of the number of perfons in New South Wales and Norfolk Ifland in April 1794, it appeared that there were in all 4414, including women and children; the annual expence of whom, to the mother-country, Mr Collins eftimates at L. 161,101. Rapid ftrides, however, were at that time making towards independence, if not towards an ability of repaying to England a part of what the fettlement had coft her. Already the colony lived on grain of its own growth, and an increafe of live ftock was become almoft certain. There were now 4665 acres of ground cleared for cultivation; more than half of which had been effected by thofe who had become fettlers in the courfe of fifteen months.

To this fpirit of improvement fuch a check was given in September 1794, that not more than a third of government ground, and a fifth of ground belonging to individuals, was in cultivation in 1795. As this event has been mifreprefented, we fufpect purpofely, by fome of our journalifts, we fhall give the true account of it in the words of Mr Collins himfelf.

"The Francis fchooner (fays he) returned from Norfolk, having been abfent about eight weeks and three days. From Mr King, who commanded in that ifland, we learned that his harveft had been prodigioufly productive. He had purchafed from the firft crops, which the fettlers had brought to market, upwards of 11,000 bufhels of maize; and bills for the amount were drawn by him in favour of the refpective fettlers; but requiring the fanction of the Lieutenant governor, they were now fent to Port Jackfon. Mr King had been partly induced to make this provifional kind of purchafe, under an idea, that the corn would be acceptable at Port-Jackfon, and alfo in compliance with the conditions on which the fettlers had received their refpective allotments under the regulations of Governor Phillip; that is to fay, that their overplus grain fhould be purchafed at a fair market price. Being, however, well ftocked with that article already, the Lieutenant governor did not think himfelf juftifiable in putting the crown to fo great an expence (nearly L.3000 Sterling), and declined accepting the bills." This naturally excited fome difcontents in Norfolk Ifland, and one or two fettlers gave up their farms; but immediately on the arrival of Governor Hunter, he paid for the corn, and tranquillity was reftored to the ifland."

Though feveral quarrels had occurred between the natives and individuals among the colonifts, yet it was fuppofed that our people were in general the aggreffors. The governor had taken much pains to infpire the natives with confidence, and had in a great meafure fucceeded. To theft they were naturally and irrefiftibly inclined: but, like other favages, they feemed unconfcious of the crime, and were feldom deterred by detection from mixing with the colonifts. At a fettlement which had early been formed at a river called the *Hawkefbury* (and at which, cultivation having gone on well, there was, in courfe, much grain to ftimulate to depredation), the natives affumed a more formidable appearance.

"At that fettlement (fays Mr Collins) an open war feemed about this time to have commenced between the natives and the fettlers; and word was received overland, that two people were killed by them; one a fettler of the name of Wilfon, and the other a freeman, one William Thorp, who had hired himfelf to this Wilfon as a labourer. The natives appeared in large bodies, men, women, and children, provided with blankets and nets to carry off the corn, of which they appeared as fond as the natives who lived among us, and feemed determined to take it whenever and wherever they could meet with opportunities. In their attacks they conducted themfelves with much art; but where that failed they had recourfe to force; and on the leaft appearance of refiftance made ufe of their fpears or clubs. To check at once, if poffible, thefe dangerous depredators. Captain Paterfon directed a party of the corps to be fent from Paramatta, with inftructions to deftroy as many as they could meet with of the wood tribe (Bè-diagal); and, in the hope of ftriking terror, to erect gibbets in different places, whereon the bodies of all they might kill were to be hung. It was reported that feveral of thefe people were killed in confequence of this order; but none of their bodies being found (perhaps if any were killed they were carried off by their companions), the number could not be afcertained. Some prifoners, however, were taken, and fent to Sydney; one man (apparently a cripple), five women, and fome children. One of the women, with a child at her breaft, had been fhot through the fhoulder, and the fame fhot had wounded the babe. They were immediately placed in a hut near our hofpital, and every care taken of them that humanity fuggefted. The man was faid, inftead of being a cripple, to have been very active about the farms, and inftrumental in fome of the murders which had been committed. In a fhort time he found means to efcape, and by fwimming reached the north fhore in fafety; whence, no doubt, he got back to his friends. Captain Paterfon hoped, by detaining the prifoners and treating them well, that fome good effect might refult; but finding, after fome time, that coercion, not attention, was more likely to anfwer his ends, he fent the women back. While they were with us, the wounded child died, and one of the women was delivered of a boy, which died immediately. On our withdrawing the party, the natives attacked a farm nearly oppofite Richmond Hill, belonging to one William Rowe, and put him and a very fine child to death; the wife, after receiving feveral wounds, crawled down the bank, and concealed herfelf among fome reeds half immerfed in the river, where fhe remained a confiderable time without affiftance: being at length found, this poor creature, after having feen her hufband and her child flaughtered before her eyes, was brought into the hofpital at Paramatta, where fhe recovered, though flowly, of her wounds."

By the vigorous meafures which were adopted, the colony, towards the clofe of 1796, had acquired a degree of ftrength which feemed to enfure its future profperity. Not only the neceffary edifices were raifed for the habitations of its people, but fome for the purpofes of religion, amufement, &c. A playhoufe had been erected at the expence of fome perfons who performed in it for their own emolument, and who admitted auditors at one fhilling each. A convenient church had been built, a printing prefs had been fet up, the civil court

court was open for the recovery of debts by action and for proving wills, licences had been issued to regulate the sale of spirits, and passage-boats were established for the convenience of communication between the different settlements. In the houses of individuals were to be found most of the comforts, and not a few of the luxuries, of life; and, in a word, the former years of famine, toil, and difficulty, were now exchanged for those of plenty, ease, and pleasure.

The quantity of ground at this time in cultivation was 5419 acres; of which 2547 were occupied by settlers. The number of persons in New South Wales and its dependencies amounted to 4848. The price of labour, however, compared with the prices of provision, (as given in Mr Collins's Tables), does not appear so high as to enable the workman to live very comfortably. He who receives but three shillings for his day's work, and gives two shillings for a pound of mutton, fifteen pence for a pound of pork, and half of that sum for a pound of flour, will scarcely derive from his mere labour the support necessary for a family.

That many things are yet wanted to give full effect to the advantages which the colony now enjoys, Mr Collins declares in the following paragraph, with which he concludes his account:

"The want at this time of several public buildings in the settlement has already been mentioned. To this want must be added, as absolutely necessary to the well-being and comfort of the settlers, and the prosperity of the colony in general, that of a public store, to be opened on a plan, though not exactly the same, yet as liberal as that of the Island of St Helena, where the East India Company issue to their own servants European and Indian goods at 10 *per cent.* advance on the prime cost. Considering our immense distance from England a greater advance would be necessary; and the settlers and others would be well satisfied, and think it equally liberal, to pay 50 *per cent.* on the prime cost of all goods brought from England; for at present they pay never less than 100, and frequently 1000, *per cent.* on what they have occasion to purchase. It may be supposed that government would not choose to open an account, and be concerned in the retail of goods; but any individual would find it to his interest to do this, particularly if assisted by government in the freight; and the inhabitants would gladly prefer the manufactures of their own country to the sweepings of the Indian bazars.

"The great want of men in the colony must be supplied as soon as a peace shall take place; but the want of respectable settlers may, perhaps, be longer felt; by these are meant men of property, with whom the gentlemen of the colony could associate, and who should be thoroughly experienced in the business of agriculture. Should such men ever arrive, the administration of justice might assume a less military appearance, and the trial by jury, ever dear and most congenial to Englishmen, be seen in New South Wales."

There is, however, one serious difficulty which the colony has not yet overcome, and which, until it be overcome, will certainly prevent such men from settling in New South Wales. Till some staple commodity can be raised for exportation, industrious free settlers will never be tempted to emigrate from Europe to a country where their industry cannot procure the comforts as well as the necessaries of life. The American colonies, in their infancy, did not labour under this disadvantage. Tobacco soon became, and still continues to be, an article of such importance, that its cultivation afforded the trans-atlantic farmer a ready exchange for European commodities; whilst in New South Wales there seems to be no vegetable production of much value, except New Zealand hemp, which is produced indeed in great abundance in Norfolk Island, and which Captain Cook long ago pointed out as an article of great importance to the British navy. This is indeed a valuable plant, and grows in all the cliffs of the island, where nothing else will grow, in sufficient abundance to give constant employment to 500 people; yet when Mr Collins left the settlement, there was no more than one loom on the island, and the slay or reed was designed for coarse canvas; nor did they possess a single tool required by flax-dressers or weavers beyond the poor substitutes which they were obliged to fabricate for themselves. In this defect of necessaries for the manufacture, only 18 people could be employed in it; and of these the united labour in a week produced 16 yards of canvas, of the size called N° 7.

Besides a useful manufactory of this plant, which certainly might be established, the colony appears to possess several important advantages. From Mr Collins's narrative, it appears probable that a seal and perhaps a whale fishery might be established with a fair prospect of success; good rich earth is found near Sydney Cove; there are immense strata of coal in the southern part of New Holland; Norfolk Island abounds with lime; and vast quantities of shells, which answer the same purpose, have been found on the main-land. Though the wood in general be not of a durable kind, it appears that there is some good timber near the Hawkesbury river; and at Norfolk Island and New-Zealand it is remarkably fine.

WALPOLE (Horace, Earl of Orford), was the youngest son of the celebrated Sir Robert Walpole, afterwards Earl of Orford, by his first wife, Catharine, daughter of Robert Shorter, Esq. of Bybrook in Kent. He was born 1716; and was educated, first at Eton school, and afterwards at Cambridge. At Eton he formed an intimate acquaintance with the celebrated poet Gray; and they went together on the tour of Europe, in the years 1739, 1740, and 1741. Unhappily they had a dispute in the course of their travels, which produced a separation.

Mr Walpole was able to make a splendid figure during the remainder of his destined course; but poor Gray, after the separation, was obliged to observe a very severe economy. "This difference arose from the difference of their tempers: the latter being, from his earliest years, curious, pensive, and philosophical; the former, gay, lively, and inconsiderate. This, therefore, occasioned their separation at Reggio. Mr Gray went before him to Venice; and staying there till he could find means of returning to England, he made the best of his way home, repassing the Alps, and following almost the same rout, through France, which he had before gone to Italy. In justice to the memory of so respectable a friend, Mr Walpole (says Mr Mason, Life of Gray, 4to, p. 41.) enjoins me to charge him with the chief blame in their quarrel, confessing that more attention, complaisance, and deference, to a warm friendship, Walpole. ſhip, and ſuperior judgment and prudence, might have prevented a rupture that gave much uneaſineſs to them both, and a laſting concern to the ſurvivor; though in the year 1744 a reconciliation was affected between them, by a lady who wiſhed well to both parties."— This event took place after their return to England; but the *wound* in their friendſhip left a *ſcar* that never was totally effaced.

We do not, indeed, think that Horace Walpole and Mr Gray were formed, either by nature or by habits, to continue long in a ſtate of intimate friendſhip. Gray appears to have been a man of the pureſt moral principles, a friend to religion, penſive, and at leaſt ſufficiently conſcious of his intellectual powers and intellectual attainments. Walpole's morality was certainly of a looſer kind; he ſeems to have had no religion; he was often unſeaſonably gay; and to an equal ſhare of intellectual pride, though without equal reaſon, he added the pride of birth. It can therefore excite no ſurpriſe that a man of Gray's independent ſpirit could not bear the ſupercilious freaks of ſuch a character.

Mr Walpole was nominated to repreſent the city of Norwich, when his father viſited it July 3d, 1733, having acquired conſequence, not only as the ſon of the miniſter, but as having attended the Prince of Orange to England in that year. He was choſen member for Collington, in Cornwall, in the parliament which met June 25th, 1741; was a ſecond time in parliament as repreſentative for Caſtle-Riſing, in Norfolk, in 1747; and for King's Lynn in 1754 and 1761; and, at the expiration of that parliament, he finally retired from the ſtage of politics, and confined himſelf wholly to literary purſuits. He held to his death the office of uſher of his Majeſty's exchequer, comptroller of the pipe, and clerk of the eſtreats. Upon the death of his nephew, George, third Earl of Orford, 1791, he ſucceeded to the title and eſtates; but that event made ſo little alteration in his mode of living, that we know not whether he ever took his ſeat in the houſe of peers. During almoſt the whole courſe of his life he was the victim of the gout, which at laſt reduced him to a cripple: but it never impaired his faculties; and, to the very moment of death, his underſtanding ſeemed to bid defiance to the ſhock of Nature. He died at his houſe in Berkeſley Square, in 1796, having juſt entered his 80th year; and was interred in the family vault at Houghton, in a private manner, agreeably to his particular directions.

Horace, Lord Orford, was never married, and, by one of his biographers, his chief miſtreſs through life is ſaid to have been the muſe It is certain that he devoted the greater part of his life to belles lettres and virtú, though he ridiculouſly affected, in his letters to his friends, to deſpiſe learning and learned men, for which he was very properly reprimanded both by Gray and Hume. It was an affectation peculiarly abſurd in him, who was conſtantly publiſhing ſomething, and who wrote with uncommon acrimony againſt all who preſumed to call in queſtion the fidelity of the picture which he had drawn of Richard III. or indeed to controvert any of his opinions. Hence his antipathy to Johnſon, becauſe he was a tory, a Chriſtian, and a rigid moraliſt; whilſt he himſelf was a whig, an infidel, and ſuch a moraliſt as could retail, without bluſhing, all the ſcandalous anecdotes, whether true or falſe, of that auguſt family, from whom he acknowledged his whole fortune to be derived. He had, indeed, another reaſon for diſliking Johnſon. Lord Orford ſhone in converſation, and ſurpaſſed all his contemporaries in that kind of talk which, without dazzling by its wit, always delighted; while Johnſon, when rouſed, knocked down, as by a flaſh of lightning, his Lordſhip, and every one elſe who had the confidence before him to talk profanely. Johnſon's wit was original; Lord Orford's conſiſted of ludicrous ſtories and of literary and political anecdotes. His works, of which by far the moſt valuable part has long been in the hands of the public, were collected in 1798, and publiſhed in five volumes 4to. They reſemble his converſation, being rather amuſing than profound or inſtructive.

Waring. WARING (Edward, M. D.), Lucaſian Profeſſor of Mathematics in the univerſity of Cambridge, was the ſon of a wealthy farmer, of the Old Heath, near Shrewſbury. The early part of his education he received at the free-ſchool in Shrewſbury; whence he removed to Cambridge, and was admitted on the 24th of March 1753 a member of Magdalen college. Here his talents for abſtruſe calculation ſoon developed themſelves, and, at the time of taking his degree, he was conſidered as a prodigy in thoſe ſciences which make the ſubject of the bachelor's examination. The name of Senior Wrangler, or the firſt of the year, was thought ſcarcely a ſufficient honour to diſtinguiſh one who ſo far outſhone his contemporaries; and the merits of John Jebb were ſufficiently acknowledged, by being the ſecond in the liſt. Waring took his firſt, or bachelor's degree, in 1757, and the Lucaſian Profeſſorſhip became vacant before he was of ſufficient ſtanding for the next, or maſter's degree, which is a neceſſary qualification for that office. This defect was ſupplied by a royal mandate, through which he became maſter of arts in 1760; and ſhortly after his admiſſion to this degree, the Lucaſian Profeſſor.

The royal mandate is too frequently a ſcreen for indolence; and it is now become almoſt a cuſtom, that heads of colleges, who ought to ſet the example in diſcipline to others, are the chief violaters of it, by making their office a pretext for taking their doctor's degree in divinity, without performing thoſe exerciſes which were deſigned as proofs of their qualifications. Such indolence cannot be imputed to Waring; yet ſeveral circumſtances, previous to his election into the profeſſorial chair, diſcovered that there was, at leaſt, one perſon in the univerſity who diſapproved of the anticipation of degrees by external influence.—Waring, before his election, gave a ſmall ſpecimen of his abilities, as proof of his qualification for the office which he was then ſoliciting; and a controverſy on his merits enſued: Dr Powell, the maſter of St John's College, attacking, in two pamphlets, the Profeſſor; and his friend, afterwards Judge Wilſon, defending. The attack was ſcarcely warranted by the errors in the ſpecimen; and the abundant proofs of talents in the exerciſe of the profeſſorial office are the beſt anſwers to the ſarcaſms which the learned divine amuſed himſelf in caſting on riſing merit. An office held by a Barrow, a Newton, a Whiſton, a Cotes, and a Sanderſon, muſt excite an ingenuous mind to the greateſt exertions; and the new Profeſſor, whatever may have been his ſucceſs, did not fall

behind

behind any of his predeceffors, in either zeal for the fcience, or application of the powers of his mind, to extend its bounderies. In 1762, he publifhed his Mifcellanea Analytica; one of the moft abftrufe books written on the abftrufeft parts of algebra. This work extended his fame over all Europe. He was elected, without folicitation on his part, member of the focieties of Bononia and Gottingen; and received flattering marks of efteem from the moft eminent mathematicians at home and abroad. The difficulty of this work may be prefumed from the writer's own words, "I cannot fay that I know any one who thought it worth while to read through the whole, and perhaps not the half of it."

Mathematics did not, however, engrofs the whole of his attention. He could dedicate fome time to the ftudy of his future profeffion; and in 1767, he was admitted to the degree of doctor of phyfic; but, whether from the incapacity of uniting together the employments of active life with abftrufe fpeculation, or from the natural diffidence of his temper, for which he was moft peculiarly remarkable; the degree which gave him the right of exercifing his talents in medicine was to him merely a barren title. Indeed he was fo embarraffed in his manners before ftrangers, that he could not have made his way in a profeffion in which fo much is done by addrefs; and it was fortunate that the cafe of his circumftances permitted him to devote the whole of his time to his favourite purfuit. His life paffed on, marked out by difcoveries, chiefly in abftract fcience; and by the publication of them in the Philofophical Tranfactions, or in feparate volumes, under his own infpection. He lived fome years after taking his doctor's degree, at St Ives, in Huntingdonfhire. While at Cambridge he married—quitted Cambridge with a view of living at Shrewfbury; but the air or fmoke of the town being injurious to Mrs Waring's health, he removed to his own eftate at Plaifley, about 8 miles from Shrewfbury, where he died in 1797, univerfally efteemed for inflexible integrity, modefty, plainnefs, and fimplicity of manners. They who knew the greatnefs of his mind from his writings looked up to him with reverence everywhere; but he enjoyed himfelf in domeftic circles with thofe chiefly among whom his purfuits could not be the object either of admiration or envy. The outward pomp which is affected frequently in the higher departments in academic life, was no gratification to one whofe habits were of a very oppofite nature; and he was too much occupied in fcience to attend to the intrigues of the univerfity. There, in all queftions of fcience, his word was the law; and at the annual examination of the candidates for the prize inftituted by Dr Smith, he appeared to the greateft advantage. The candidates were generally three or four of the beft proficients in the mathematics at the previous annual examination for the bachelor's degree, who were employed from nine o'clock in the morning to ten at night, with the exception of two hours for dinner, and twenty minutes for tea, in anfwering, *viva voce*, or writing down anfwers to the profeffor's queftions, from the firft rudiments of philofophy to the deepeft parts of his own and Sir Ifaac Newton's works. Perhaps no part of Europe affords an inftance of fo fevere a procefs; and there was never any ground for fufpecting the Profeffor of partiality. The zeal and judgment with which he performed this part of his office cannot be obliterated from the memory of thofe who paffed through his fiery ordeal.

Wifhing to do ample juftice to the talents and virtue of the Profeffor, we feel ourfelves fomewhat at a lofs in fpeaking of the writings by which alone he will be known to pofterity. He is the difcoverer, according to his own account, of nearly 400 propofitions in the analytics. This may appear a vain glorious boaft, efpecially as the greater part of thofe difcoveries are likely to fink into oblivion; but he was, in a manner, compelled to make it by the infolence of Lalande, who, in his life of Condorcet, afferts that, in 1764, there was no firft-rate analyft in England. In reply to this affertion, the Profeffor, in a letter to Dr Mafkelyne, firft mentions, with proper refpect, the inventions and writings of Harriot, Briggs, Napier, Wallis, Halley, Brunker, Wren, Pell, Barrow, Mercator, Newton, De Moivre, Maclaurin, Cotes, Stirling, Taylor, Simpfon, Emerfon, Landen, and others; of whom Emerfon and Landen were living in 1764. He then gives a fair and full detail of his own inventions, of which many were publifhed anterior to 1764; and concludes his letter in thefe words.

"I know that Mr Lalande is a firft-rate aftronomer, and writer of aftronomy; but I never heard that he was much converfant in the deeper parts of mathematics; for which reafon I take the liberty to afk him the following queftions:

"Has he ever read or underftood the writings of the Englifh mathematicians: and, as the queftion comes from me, I fubjoin, particularly of mine? If the anfwer be in the negative, as it is my opinion, if his anfwer be the truth, that it will, then there is an end of all further controverfy;—but if he afferts that he has, which is more than Condorcet did by his own acknowledgment, then he may know, from the enumeration of inventions made in the prefaces, with fome fubfequent ones added, that they are faid to amount to more than 400 of one kind or other. Let him try to reduce thofe to as low a number as he can, with the leaft appearance of candour and truth; and then let him compare the number with the number of inventions of any French mathematician or mathematicians, either in the prefent or paft times, and there will refult a comparifon (if I miftake not) not much to his liking; and, further, let him compare fome of the firft inventions of the French mathematicians with fome of the firft contained in my works, both as to utility, generality, novelty, difficulty, and elegance, but wifely as to utility, there is little contained in the deep parts of any fcience; he will find their difficulty and novelty from his difficulty of underftanding them, and his never having read any thing fimilar before; their generality, by the application of them; principles of elegance will differ in different perfons.—I muft fay, that he will probably not find the difference expected. After or before this inquiry is inftituted for mine, let him perform the fame for the other Englifh mathematicians; and when he has completed fuch inquiries, and not before, he will become a judge of the juftice of his affertion; but I am afraid that he is not a fufficient adept in thefe ftudies to inftitute fuch inquiries; and if he was, fuch inquiries are invidious, troublefome, and of fmall utility."

By mathematical readers this account, which was not publifhed publiſhed by the Profeſſor himſelf, is allowed to be very little, if at all, exaggerated. Yet if, according to his own confeſſion, "few thought it worth their while to read even half of his works," there muſt be ſome grounds for this neglect, either from the difficulty of the ſubject, the unimportance of the diſcoveries, or a defect in the communication of them to the public. The ſubjects are certainly of a difficult nature, the calculations are abſtruſe; yet Europe contained many perſons not to be deterred by the moſt intricate theorems. Shall we ſay, then, that the diſcoveries were unimportant? If this were really the caſe, the want of utility would be a very ſmall diſparagement among thoſe who cultivate ſcience with a view chiefly to entertainment and the exerciſe of their rational powers. We are compelled, then, to attribute much of this neglect to a perplexity in ſtyle, manner, and language; the reader is ſtopped at every inſtant, firſt to make out the writer's meaning, then to fill up the chaſm in the demonſtration. He muſt invent anew every invention; for, after the enunciation of the theorem or problem, and the mention of a few ſteps, little aſſiſtance is derived from the Profeſſor's powers of explanation. Indeed, an anonymous writer, certainly of very conſiderable abilities, has aptly compared the works of Waring to the heavy appendages of a Gothic building, which add little of either beauty or ſtability to the ſtructure.

A great part of the diſcoveries relate to an aſſumption in algebra, that equations may be generated by multiplying together others of inferior dimenſions. The roots of theſe latter equations are frequently terms called *negative* or *impoſſible;* and the relation of theſe terms to the coefficients of the principal equation is a great object of inquiry. In this art the profeſſor was very ſucceſsful, though little aſſiſtance is to be derived from his writings in looking for the real roots. We ſhall not, perhaps, be deemed to depreciate his merits, if we place the ſeries for the ſum of the powers of the roots of any equation among the moſt ingenious of his diſcoveries; yet we cannot add, that it has very uſefully enlarged the bounds of ſcience, or that the algebraiſt will ever find occaſion to introduce it into practice. We may ſay the ſame on many ingenious transformations of equations, on the diſcovery of impoſſible roots, and ſimilar exertions of undoubtedly great talents. They have carried the aſſumption to its utmoſt limits; and the difficulty attending the ſpeculation has rendered perſons more anxious to aſcertain its real utility; yet they who reject it may occaſionally receive uſeful hints from the Miſcellanea Analytica.

The firſt time of Waring's appearing in public as an author was, we believe, in the latter end of the year 1759, when he publiſhed the firſt chapter of the Miſcellanea Analytica, as a ſpecimen of his qualifications for the profeſſorſhip; and this chapter he defended, in a reply to a pamphlet, intitled, "Obſervations on the Firſt Chapter of a book called Miſcellanea Analytica." Here the Profeſſor was ſtrangely puzzled with the common paradox, that nothing divided by nothing may be equal to various finite quantities, and has recourſe to unqueſtionable authorities in proof of this poſition. The names of Maclaurin, Sanderſon, De Moivre, Bernoulli, Monmort, are ranged in favour of his opinion: But Dr Powell was not ſo eaſily convinced, and returns to the charge in defence of the Obſervations; to which the Profeſſor replied in a letter to the Rev. Dr Powell, Fellow of St John's college, Cambridge, in anſwer to his obſervations, &c. In this controverſy, it is certain that the Profeſſor gave evident proofs of his abilities; though it is equally certain that he followed too implicitly the deciſions of his predeceſſors. No apparent advantage, no authority whatever, ſhould induce mathematicians to ſwerve from the principles of right reaſoning, on which their ſcience is ſuppoſed to be peculiarly founded. According to Maclaurin, Dr Waring, and others, If $P = \frac{a-x}{a^2-x^2}$, then, when $x = a$, P is equal to $\frac{1}{2a}$; for, ſay they, $\frac{a-x}{a^2-x^2}$ is equal to $\frac{a-x}{a-x} \times \frac{1}{a+x}$; that is, when x is equal to a, $P = \frac{1}{a+x}$, or $\frac{1}{2a}$. But when x is equal to a, the numerator and denominator of the fraction $\frac{a-x}{a^2-x^2}$ are both, in their language, equal to nothing. Therefore, nothing divided by nothing is equal to $\frac{1}{2a}$. In the ſame manner, $\frac{a-x}{a^3-x^3} = \frac{1}{a^2+ax+x^2} \times \frac{a-x}{a-x}$, which, when x is equal to a, becomes $\frac{1}{3a^2}$. Therefore, nothing divided by nothing is equal to $\frac{1}{3a^2}$, or $\frac{1}{3a^2} = \frac{1}{2a}$; that is, $\frac{1}{3a} = \frac{1}{2}$; which is abſurd. But we need only trace back our ſteps to ſee the fallacy in this mode of reaſoning. For P is equal to ſome number multipled into $\frac{a-x}{a-x}$; that is, when x is equal to a, P is equal to ſome number multiplied into nothing, and divided by nothing; that is, P is, in that caſe, no number at all. For $a - a$ cannot be divided by $a - x$ when x is equal to a, ſince, in that caſe, $a - x$ is no number at all.

If, in the beginning of his career, the Profeſſor could admit ſuch paralogiſms into his ſpeculations, and the writings of the mathematicians, for nearly a century before him, may plead in his excuſe, we are not to be ſurpriſed that his diſcoveries ſhould be built rather on the aſſumptions of others than on any new principles of his own. Acquieſcing in the ſtrange notion, that nothing could be divided by nothing, and produce a variety of numbers, he as eaſily adopted the poſition, that an equation has as many roots as it has dimenſions.— Thus 2 and — 4 are ſaid to be roots of the equation $x^2 - 2x = 8$, though 4 can be the root only of the equation; $x^2 - 2x = 8$, which differs ſo materially from the preceding, that in one caſe $2x$ is added, in the other caſe it is ſubtracted from x^2.

Allowances being made for this error in the principles, the deductions are, in general, legitimately made; and any one, who can give himſelf the trouble of demonſtrating the propoſitions, may find ſufficient employment in the Profeſſor's analytics. Perhaps it will be ſufficient for a ſtudent to devote his time to the ſimpleſt caſe $x^n + 1 = 0$; and when he has found a few thouſand roots of + 1 and — 1, the publication of them may afford to poſterity a ſtrong proof of the ingenuity

ingenuity of their predeceffors, and the application of the powers of their mind to ufeful and important truths In this exercife may be confulted the method given by the Profeffor, of finding a quantity, which, multiplied into a given irrational quantity, will produce a rational product, or confequently exterminate irrational quantities out of a given equation ; but if an irrational quantity cannot come into an equation, the utility of this invention will not be admitted without hefitation.

The "Proprietates Algebraicarum Curvarum," publifhed in 1772, neceffarily labour under the fame defects with the Mifcellanea Analytica, the Meditationes Algebraicæ, publifhed in 1770, and the Meditationes Analyticæ, which were in the prefs during the years 1773, 1774, 1775, 1776. Thefe were the chief and the moft laborious works edited by the Profeffor; and in the Philofophical Tranfactions is to be found a variety of papers, which alone would be fufficient to place him in the firft rank in the mathematical world. The nature of them may be feen from the following catalogue.

Vol. LIII. p. 294, Mathematical Problems.—LIV. 193. New properties in Conics.—LV. 143. Two Theorems in Mathematics.—LXIX. Problems concerning Interpolations.—86. A General Refolution of Algebraical Equations.—LXXVI. 81. On Infinite Series. LXXVII. 71. On Finding the Values of Algebraical Quantities by Converging Seriefes, and Demonftrating and Extending Propofitions given by Pappus and others.—LXXVIII. 67. On Centripetal Forces. *Ib.* 588. On fome Properties of the Sum of the Divifion of Numbers.—LXXIX. 166. On the method of Correfpondent Values, &c.—*Ib.* 185. On the Refolution of Attractive Powers.—LXXXI. 146. On Infinite Seriefes.—LXXXIV. 385—415. On the Summation of thofe Seriefes whofe general term is a determinate function of z, the diftance of the term of the Series.

For thefe papers, the Profeffor was, in 1784, defervedly honoured by the Royal Society with Sir Godfrey Copley's medal ; and moft of them afford very ftrong proofs of the powers of his mind, both in abftract fcience, and the application of it to philofophy ; though they labour, in common with his other works, under the difadvantage of being clothed in a very unattractive form. The mathematician, who has refolution to go through them, will not only add much to his own knowledge, but be ufefully employed in dilating on thofe articles for the benefit of the more general reader. We might add in this place, a work written on morals and metaphyfics in the Englifh language ; but as a few copies only were prefented to his friends, and it was the Profeffor's wifh that they fhould not have a more extenfive circulation, we fhall not here enlarge upon its contents.

In the mathematical world, the life of Waring may be confidered as a diftinguifhed æra. The ftrictnefs of demonftration required by the ancients had gradually fallen into difufe, and a more commodious, though almoft mechanical mode by algebra and fluxions took its place, and was carried to the utmoft limit by the Profeffor. Hence many new demonftrations may be attributed to him, but 400 difcoveries can fcarcely fall to the lot of a human being. If we examine thoroughly thofe which our Profeffor would diftinguifh by fuch names, we fhall find many to be mere deductions, others, as in the folution of biquadratics, anticipated by former writers. But if we cannot allow to him the merit of fo inventive a genius, we muft applaud his affiduity ; and, diftinguifhed as he was in the fcientific world, the purity of his life, the fimplicity of his manners, and the zeal which he always manifefted for the truths of the Gofpel, will intitle him to the refpect of all who do not efteem the good qualities of the heart inferior to thofe of the head.

WARTON (Jofeph, D. D.) was born either towards the end of the year 1721, or in the beginning of the year 1722. He was the eldeft fon of Thomas Warton, B. D. who had been fellow of Magdalen College, Oxford ; poetry profeffor from the year 1718 to 1728, and vicar of Bafingftoke in Hampfhire, and of Cobham in Surrey. Where the fubject of this memoir was born we have not learned, though, were we to hazard a conjecture, we would fay that it was in Oxford, as his father probably refided in that city during his profefforfhip.

Our knowledge of the private hiftory of Dr Warton is indeed extremely limited. We do not even know at what fchool, or in what college, he was educated ; tho' it was probably at Winchefter fchool, and certainly in fome of the colleges in the univerfity of Oxford. For many years, he was fucceffively under and upper mafter of Winchefter college ; but refigned the laft of thefe offices when he found the infirmities of age coming upon him ; and was fucceeded by Dr Goddard the prefent excellent mafter. He was likewife prebendary of the cathedral church of Winchefter, and rector of Wickham in Hampfhire, where he died, aged 78.

His publications are few, but valuable. A fmall collection of poems, without a name, was the firft of them, and contained the Ode to Fancy, which has been fo much and fo defervedly admired. They were all of them afterwards printed in Dodfley's collection. He was alfo a confiderable contributor to the Adventurer, publifhed by Dr Hawkefworth ; and all the papers which contain criticifms on Shakefpeare were written by him and his brother Thomas Warton, the fubject of the next article.

The firft volume of his Effay on the Life and Writings of Pope was publifhed, had paffed through feveral editions, and an interval of between 20 and 30 years had elapfed, before he gave a fecond volume of that elegant and inftructive work to the world. He had not only meditated, but had collected materials for a literary hiftory of the age of Leo X. ; and propofals were actually in circulation for a work of that kind ; but it is probable that the duties of his ftation did not leave him the neceffary leifure for an undertaking which required years of feclufion and independence. His laft and late work, which he undertook for the bookfellers at a very advanced age, was an edition of Pope's Works, that has not altogether fatisfied the public expectation. He retained, with great propriety indeed, many of the notes of Warburton ; but is feverely reprehended by the author of the Purfuits of Literature for fuppreffing the name of that prelate on his title-page, or including it only, as fubordinate to his own, in the general expreffion *others*.

Dr Warton was cheerful in his temper, convivial in his difpofition, of an elegant tafte and lively imagination, with a large portion of fcholarfhip, and a very general

Warton. general knowledge of the Belles Lettres of Europe; it may be presumed that Dr Warton possessed, beyond most men, the power of enlivening Classical Society. He was the intimate friend of Dr Johnson; was seen at the parties of Mrs Montague, as well as at the table of Sir Joshua Reynolds, and was an original member of the Literary Club. He possessed a liberal mind, a generous disposition, and a benevolent heart. He was not only admired for his talents and his knowledge, but was beloved for those qualities which are the best gifts of this imperfect state.

WARTON (Thomas) the brother of the preceding, was born in the year 1728. He received, as we have reason to believe, the first part of his education at Winchester; and at the age of 16 was entered a commoner *Biog. Dict.* of Trinity College, Oxford, under the tuition of Mr Geering.

He began his poetical career at an early age. In 1745, he published five pastoral eclogues, in which are beautifully described the miseries of war to which the shepherds of Germany were exposed. Not long after, in the year 1748, he had full scope afforded for the exertion of his genius. It is well known that Jacobite principles were suspected to prevail in the university of Oxford about the time of the rebellion in the year 1745. Soon after its suppression, the drunkenness and folly of some young men gave offence to the court, in consequence of which a prosecution was instituted in the court of King's Bench, and a stigma was fixed on the vice chancellor and some other heads of colleges in Oxford. Whilst this affair was the general subject of conversation, Mr Mason published his "Isis," an elegy, in which he adverts to the above-mentioned circumstances. In answer to this poem, Mr Warton, encouraged by Dr Huddesford, the president of his college, published, in 1749, "The Triumph of Isis," which excelled more in manly expostulation and dignity than the poem that produced it did in neatness and elegance. With great poetical warmth, and a judicious selection of circumstances, he characterises the eminent men who had been educated in Oxford, and draws a striking and animated portrait of Dr King, the celebrated public orator of that time. The whole poem shews the early maturity of his genius, and is finished with happy diligence.

In the year 1751, he succeeded to a fellowship of his college, and was thus placed in a situation easy and independent, and particularly congenial with his habits of retirement and study. In 1753, appeared his observations on "The Faery Queen of Spencer," in 8vo, a work which he corrected, enlarged, and republished, in two volumes crown octavo, in the year 1762. He sent a copy of the first edition to Dr Johnson, who, in a letter to him upon the subject, expressed this handsome compliment: "I now pay you a very honest acknowledgment for the advancement of the literature of our native country: you have shewn to all, who shall hereafter attempt the study of ancient authors, the way to success, by directing them to the perusal of the books which these authors had read."

In 1754, Dr Johnson visited Oxford for the first time after he had quitted residence there. Much of his time was spent with Mr Warton; and there appeared to have been a considerable degree of confidential intercourse between them upon literary subjects, and particularly on their own works. A pleasing account of Warton this visit was communicated by Mr Warton to Mr Boswell, who has inserted it in his life of Johnson.

In 1755, Mr Warton exerted himself to procure for his friend the degree of master of arts by diploma from the university of Oxford; an honour which Johnson esteemed of great importance to grace the title page of his dictionary which he was about to publish. In 1756, Mr Warton was elected professor of poetry, which office he held for the usual term of ten years. His lectures were remarkable for elegance of diction and justness of observation. One of them, on the subject of pastoral poetry, was afterwards prefixed to his edition of Theocritus. In 1758, he contributed to assist Dr Johnson in the subscription to his edition of Shakespeare, and furnished him with some valuable notes. The Doctor remarks, in a letter to him, when soliciting his farther aid, "It will be reputable to my work, and suitable to your professorship, to have something of yours in my notes."

From the Clarendon press, in the year 1766, he published "Anthologiæ Græcæ, a Constantino Cephalâ conditæ, Libri tres," in 2 vols, 12mo. He concludes the learned and classical preface to this work, which is replete with accurate remarks on the Greek epigram, in the following words, which mark this publication for his own: "Vereor ut hactenus in plexendis florum corollis otium nimis longum pertraxerim. Proximè sequetur, cui nunc omnes operas et vires intendo, Theocritus. Interea quasi promulsidem convivii Lectoribus meis elegantias hasce vetustatis eruditæ propino.

In the year 1770, he conferred a similar honour upon the academical press by his edition of Theocritus, in 2 vols, 8vo. He undertook this work by the advice of Judge Blackstone, then fellow of All Souls College, and an ardent promoter of every publication that was likely to do credit to the Clarendon press. This elaborate publication reflects no small credit on the learning, diligence, and taste of the editor.

In 1771, he was elected a fellow of the Antiquarian Society, and was presented by the Earl of Litchfield to the small living of Kiddington in Oxfordshire, which he held till his death. He likewise in this year published an improved account of "The Life of Sir Thomas Pope, founder of Trinity College, Oxford. In composing these memoirs, he bestowed much labour and research, and shewed great judgment in the arrangement of his materials. But possibly, in his ardour to pay a debt of gratitude, he has not sufficiently considered what was due to his own fame. The same strength of description and vigour of remark would have better suited the life of some eminently distinguished character, and extended the reputation of the author as a biographer beyond the circle of those academical readers who are influenced by the same feelings of veneration, respect, and gratitude which prompted Mr Warton to compose this work. The preface contains some excellent remarks on biographical writing.

The plan for a history of English poetry was laid by Pope, enlarged by Gray: but to bring an original plan nearly to a completion was reserved for the perseverance of Warton. In 1744 appeared his first volume; in 1778, the second and third; which brings the narrative down to the commencement of the reign of Elizabeth in

Warton.

in 1581. This work difplays the moft fingular combination of extraordinary talents and attainments. It unites the deep and minute refearches of the antiquary with the elegance of the claffical fcholar and the fkill of the practifed writer. The ftyle is vigorous and manly; the obfervations acute and juft; and the views of the fubject are extenfive and accurate.

In 1777, he collected his poems into an octavo volume, containing mifcellaneous pieces, odes, and fonnets. This publication may be confidered in fome meafure original; there being only feven pieces that had before appeared, and near three times that number which were then printed for the firft time.

In vindication of the opinion he had given in his fecond volume of "The Hiftory of Poetry," relative to the ingenious attempt of Chatterton to impofe upon the public, he produced, in 1782, "An Inquiry into the Authenticity of the Poems attributed to Rowley." In this excellent pamphlet the principles of true criticifm are laid down, an appeal is properly made to the internal evidence of the poems; and upon thefe grounds it is proved, in the moft fatisfactory manner, that they could not have been written by a monk of the fourteenth century.

The year 1785 brought him thofe diftinctions which were no lefs honourable to thofe who conferred than to him who received them. He was appointed poet-laureat on the death of Whitehead, and elected Camden profeffor of ancient hiftory on the refignation of Dr Scott. His inauguration lecture was delivered in a clear and impreffive manner from the profefforial chair. It contained excellent obfervations on the Latin hiftorians, and was written in a ftrong, perfpicuous, and claffical ftyle. In his odes, the vigour and brilliancy of his fancy were not proftituted to an infipid train of courtly complements: each prefents an elegant fpecimen of defcriptive poetry, and as all of them have only a flight relation to the particular occafion on which they were written, and have always a view to fome particular and interefting fubject, they will be perufed with pleafure as long as this fpecies of compofition is admired.

He made occafional journeys to London to attend the literary club, of which he was fome years a member; and to vifit his friends, particularly Sir Jofhua Reynolds. At his houfe he was fure to meet perfons remarkable for fafhion, elegance, and tafte.

His laft publication, except his official odes, confifted of Milton's fmaller poems. A quarto edition appeared in 1790, with corrections and additions. The great object of thefe notes is to explain the allufions of Milton, to trace his imitations, and to illuftrate his beauties.

Until he reached his fixty fecond year, he continued to enjoy vigorous and uninterrupted health. On being feized with the gout, he went to Bath, and flattered himfelf, on his return to college, that he was in a fair way of recovery. But the change that had taken place in his conftitution was vifible to his friends. On Thurfday, May 20, 1790, he paffed the evening in the common room, and was for fome time more cheerful than ufual. Between ten and eleven o'clock he was ftruck with the palfy, and continued infenfible till his death, which happened the next day at two o'clock. On the 27th, his remains were interred in the college chapel with the moft diftinguifhed academical honours. The infcription upon the flat ftone which is placed over his grave contains only an enumeration of his preferments.

Such was the general conduct and behaviour of Mr Warton as to render him truly amiable and refpectable. By his friends he was beloved for his open and eafy manners; and by the members of the univerfity at large he was refpected for his conftant refidence, ftrong attachment to Alma Mater, his ftudious purfuits, and high literary character. In all parties where the company accorded with his inclination, his converfation was eafy and gay, enlivened with humour, enriched with anecdote, and pointed with wit. Among his peculiarities it may be mentioned that he was fond of all military fights. He was averfe to ftrangers, particularly to thofe of a literary turn; and yet he took a great pleafure in encouraging the efforts of rifing genius, and affifting the ftudious with his advice; as many of the young men of his college, who fhared his affability and honoured his talents, could teftify. He was bred in the fchool of punfters; and made as many good ones as Barton and Leigh, the celebrated word-hunters of his day. Under the mafk of indolence, no man was more bufy; his mind was ever on the wing in fearch of fome literary prey. Although, at the accuftomed hours of Oxford ftudy, he was often feen fauntering about, and converfing with any friend he chanced to meet; yet, when others were wafting their mornings in fleep, he was indulging his meditations in his favourite walks, and courting the Mufes. His fituation in Oxford was perfectly congenial with his difpofition, whether he indulged his fallies of pleafantry in the common room, retired to his own ftudy, or to the Bodleian library; fauntered on the banks of his favourite Cherwell, or furveyed, with the enthufiaftic eye of tafte, the ancient gateway of Magdalen College, and other fpecimens of Gothic architecture.

The following is a lift of Mr Warton's works: 1. "Five Paftoral Eclogues," 4to, 1745. Reprinted in Pearch's Collection of Poems. 2. "The Pleafures of Melancholy," written in 1745; firft printed in Dodfley's Collection, and afterwards in the Collection of Mr Warton's Poems. 3. "Progrefs of Difcontent," written in 1746. Firft printed in the "Student," a periodical paper. 4. "The Triumph of Ifis, a Poem," 4to, 1750. 5. "Newmarket, a Satire," folio, 1751. 6. "Ode for Mufic," performed at the theatre in Oxford 1751. 7. "Obfervations on the Faerie Queen of Spenfer," 8vo, 1754. 8. "Infcriptionum Metricarum Delectus," 4to, 1758. 9. "A Defcription of the City, College, and Cathedral, of Winchefter," 8vo, no date. 10. "The Life of Sir Thomas Pope," in the 5th volume of the Biographia Britannica," republifhed in 1772. 11. "The Life and literary Remains of Ralph Bathurft, M. D. Dean of Wells, and Prefident of Trinity College in Oxford," 1761. 12. "A Companion to the Guide, and a Guide to the Companion," 12mo, 1762. 13. "The Oxford Saufage," in which are feveral Poems by Warton. 14. "Anthologiæ Græcæ a Conftantino Cephalâ conditæ Libri tres," 2 tom. 1766. 15. "Theocritis Syracufii quæ fuperfunt, cum Scholiis Græcis," &c. 2 tom. 4to, 1770. 16. "Hiftory of Englifh Poetry, from the Clofe of the 11th to the Commencement of the 18th Century," 4to, Vol. I. 1774. Vol. II. 1778. Vol. III. 1781. 17. "Poems," 8vo, 1777. 18. "Specimen of a

Hiftory

Hiſtory of Oxfordſhire," 1783. 19. "An Enquiry into the Authenticity of the Poems attributed to Thomas Rowley," 8vo, 1782. 20. Verſes on Sir J. Reynolds's painted Window in New College Chapel, 4to," 1782. 21. "Poems on ſeveral Occaſions, by John Milton, with Notes critical and explanatory," 8vo, 1785.

WASHINGTON (George), whoſe name is likely to live as long as that of any modern, was born on the 11th of February 1732, in the pariſh of Waſhington, Virginia. He was deſcended from an ancient family in Cheſhire, of which a branch had been eſtabliſhed in Virginia about the middle of the 17th century. We are not acquainted with any remarkable circumſtances of his education or his early youth; and we ſhould not indeed expect any marks of that diſorderly prematureneſs of talent, which is ſo often fallacious, in a character whoſe diſtinguiſhing praiſe was to be regular and natural. His claſſical inſtruction was probably ſmall, ſuch as the private tutor of a Virginian country gentleman could at that period have imparted; and if his opportunities of information had been more favourable, the time was too ſhort to profit by them (A). Before he was twenty he was appointed a major in the colonial militia, and he had very early occaſion to diſplay thoſe political and military talents, of which the exertions on a greater theatre have ſince made his name ſo famous throughout the world.

The plenipotentiaries who framed the treaty of Aix la Chapelle, by leaving the boundaries of the Britiſh and French territories in North America unfixed, had ſown the ſeeds of a new war, at the moment when they concluded a peace.—The limits of Canada and Louiſiana, negligently deſcribed in vague language by the treaties of Utrecht and Aix la Chapelle, becauſe the greater part of theſe vaſt countries was then an impenetrable wilderneſs, furniſhed a motive, or a pretext, for one of the moſt ſucceſsful, but one of the moſt bloody and waſteful wars in which Great Britain had ever been engaged. See BRITAIN, *Encycl.*

In the diſputes which aroſe between the French and Engliſh officers on this ſubject, Major Waſhington was employed by the governor of Virginia, in a negociation with the French governor of Fort du Queſne (now Pitſburgh); who threatened the Engliſh frontiers with a body of French and their Indian allies. He ſucceeded in averting the invaſion; but hoſtilities becoming inevitable, he was in the next year appointed lieutenant colonel of a regiment raiſed by the colony for its own defence; to the command of which he ſoon after ſucceeded. The expedition of Braddock followed in the year 1755; of which the fatal iſſue is too well known to require being deſcribed by us. Colonel Waſhington ſerved in that expedition only as a volunteer; but ſuch was the general confidence in his talents, that he may be ſaid to have conducted the retreat. Several Britiſh officers are ſtill alive who remember the calmneſs and intrepidity which he ſhewed in that difficult ſituation, and the voluntary obedience which was ſo cheerfully paid by the whole army to his ſuperior mind. After having acted a diſtinguiſhed part in a ſubſequent and more ſucceſsful expedition to the Ohio, he was obliged by ill health, in the year 1758, to reſign his military ſituation. The ſixteen years which followed of the life of Waſhington ſupply few materials for the biographer. Having married Mrs Cuſtis, a Virginian lady of amiable character and reſpectable connections, he ſettled at his beautiful ſeat of Mount Vernon, of which we have had ſo many deſcriptions; where, with the exception of ſuch attendance as was required by his duties as a magiſtrate and a member of the aſſembly, his time was occupied by his domeſtic enjoyments, and the cultivation of his eſtate, in a manner well ſuited to the tranquillity of his pure and unambitious mind. At the end of this period he was called by the voice of his country from this ſtate of calm and ſecure though unoſtentatious happineſs.

For almoſt half a century ſymptoms of diſaffection to the mother-country had been ſo viſible in the New England provinces, that ſo early as 1734 the celebrated Biſhop Berkeley had predicted a total ſeparation of North America from Great Britain. That prelate, when a private clergyman, had lived three years in Rhode Iſland, and was an attentive and ſagacious obſerver of the manners and principles of the people, among whom he perceived the old leaven of their forefathers fermenting even then with great violence. The middle and ſouthern provinces, however, were more loyal, and their influence, together with perpetual dread of the French before the peace of 1763, put off the ſeparation to a more diſtant day than that at which, we have reaſon to believe, the Biſhop expected it to take place. Virginia, the moſt loyal of all the colonies, had long been in the habit of calling itſelf, with a kind of proud pre-eminence, *his Majeſty's ancient dominion*; and it was with ſome difficulty that the demagogues of New England could gain over that province when the time arrived for effecting their long meditated revolt. At laſt, however, they ſucceeded; and we find Mr Waſhington as a delegate from Virginia in the Congreſs which met at Philadelphia on the 26th of October 1774. (See AMERICA, n° 174. *Encycl.*) As no American united in ſo high a degree as he did, military experience with reſpectability of character, he was appointed to the command of the army which had aſſembled in the New England provinces, to hold in check the Britiſh army which was then encamped under General Gage at Boſton.

At this period there is ſome reaſon to believe that neither Mr Waſhington nor his conſtituents entered heartily into the views of the New Englanders; but afraid leſt the army of thoſe rebellious fanatics, after ſhaking off the yoke of Great Britain, might give law to the continent, he took upon himſelf the command of that army in the

 month

(A) Several accounts of the life of Waſhington have ſtated that he ſerved as a midſhipman on board a Britiſh frigate. This is a miſtake. His elder brother, who died young, ſerved in that capacity in Vernon's expedition againſt Carthagena; whence the family ſeat was called Mount Vernon. Waſhington himſelf never left the United States, except in one ſhort voyage to a Weſt India iſland, when he was very young.

Washington.

month of July 1775 (B). To detail his conduct in the years which followed, would be to relate the history of the American war, which we have already related in the article AMERICA (*Encycl.*). Within a very short period after the declaration of independence, the affairs of America were in a condition so desperate, that perhaps nothing but the *peculiar* character of Washington's genius could have retrieved them. Activity was the policy of invaders. In the field of battle the superiority of a disciplined army is displayed. But delay was the wisdom of a country defended by undisciplined soldiers against an enemy who must be more exhausted by time than he could be weakened by defeat. It required the consummate prudence, the calm wisdom, the inflexible firmness, the moderate and well balanced temper of Washington to embrace such a plan of policy, and to persevere in it: to resist the temptations of enterprize; to fix the confidence of his soldiers without the attraction of victory; to support the spirit of the army and the people amidst those slow and cautious plans of defensive warfare which are more dispiriting than defeat itself; to contain his own ambition and the impetuosity of his troops; to endure temporary obscurity for the salvation of his country, and for the attainment of solid and immortal glory; and to suffer even temporary reproach and obloquy, supported by the approbation of his own conscience and the applause of that small number of wise men, whose praise is an earnest of the admiration and gratitude of posterity. Victorious generals easily acquire the confidence of their army. Theirs, however, is a confidence in the *fortune* of their general. That of Washington's army was a confidence in his *wisdom*. Victory gives spirit to cowards, and even the agitations of defeat sometimes impart a courage of despair. Courage is inspired by success, and it may be stimulated to desperate exertion even by calamity; but it is generally palsied by inactivity.—A system of cautious defence is the severest trial of human fortitude; and by this test the firmness of Washington was tried. It must not, however, be concealed, that some of the British commanders gave him advantages, which he surely did not expect; for more than once, as it appears to us, they had it in their power to annihilate his army, merely by following up their victories. The issue of the contest is known.

Much has been said by the British and American democrates of the magnanimity of Washington during the ravages of a civil war, in which he acted so conspicuous a part; and we feel not ourselves inclined to refuse him the praise which he may have merited on this or on any other account. But granting that duty required him to execute as a spy the accomplished *Andre*, true magnanimity would have prevented him from insultingly erecting, in the view of that unfortunate officer, the gallows on which he was to be hung, several days before his execution! When Earl Cornwallis was overpowered by numbers, and obliged at York-town to surrender to the united armies of America and France, a magnanimous conqueror would not have maliciously claimed, contrary to the usage of civilized war, the sword from the hands of that gallant nobleman. On these two occasions, and on some others, the conduct of Washington agreed so ill with his general character, that we are inclined to believe that he must have been influenced by the leaders of the French army Rochembeau and Fayette. One thing is certain, that he was so little pleased either with his own conduct on particular occasions, or with the general principle of the American revolution, that he never could be forced to talk on the subject. An Italian nobleman, who visited him after the peace, had often attempted, in vain, to turn the conversation to the events of the war. At length he thought he had found a favourable opportunity of effecting his purpose; they were riding together over the scene of an action where Washington's conduct had been the subject of no small animadversion. Count ——— said to him, "Your conduct, Sir, in this action has been criticised." Washington made no answer, but clapped spurs to his horse; after they had passed the field, he turned to the Italian and said, "Count ———, I observe that you wish me to speak of the war; it is a conversation which I always avoid. I rejoice at the establishment of the liberties of America. But the time of the struggle was a horrible period, in which the best men were compelled to do many things repugnant to their nature." This, we think, is the language of a good man not altogether satisfied with the part which he had been compelled to act, and who though he rejoiced at the establishment of the *liberties* of America, probably foresaw that she would reap no benefit from her favourite *independence*.

The conclusion of the American war permitted Washington to return to those domestic scenes, from which no views of ambition seem to have had the power to draw him. But he was not allowed long to enjoy this privacy. The supreme government of the United States, hastily thrown up, in a moment of turbulence and danger, as a temporary fortification against anarchy, proved utterly inadequate to the preservation of general tranquillity and permanent security. The confusions of civil war had given a taint to the morality of the people, which rendered the restraints of a just and vigorous government more indispensably necessary. Confiscation and paper money, the two greatest schools of rapacity and dishonesty in the world, had widely spread their poison among the Americans. One of their own writers tells us, that the whole system of paper money was a system of public and private frauds. In this state of things, which threatened the dissolution of morality and government, good men saw the necessity of concentrating and invigorating the supreme authority. Under the influence of this conviction, a convention of delegates was assembled at Philadelphia, which strengthened the bands of the Federal Union, and bestowed on Congress those powers which were necessary for the purposes of good government. Washington was the president of this convention, as he, in three years after, was elected president of the United States of America, under what was called "The New Constitution," tho' it ought to have been called a *reform* of the republican government,

(B) That such were the motives of his conduct on this occasion, is rendered in the highest degree probable in the preface to *A View of the Causes and Consequences of the American Revolution, in thirteen Discourses, Preached in North America, between the years* 1763 and 1775; by Jonathan Boucher, A. M. and F. A. S. Vicar of Epsom in the County of Surrey.

Washington. government, as that republican government itself was only a *reform* of the ancient colonial constitution under the British crown. None of these changes extended so far as an attempt to new-model the whole social and political system.

Events occurred during his chief magistracy which convulsed the whole political world, and which tried most severely his moderation and prudence. The French revolution took place; Washington, who had experienced the evils of one revolution, augured, from the beginning, no good from the daring speculations of inexperienced visionaries; and the progress of the revolution was not calculated to cure his distrust. When, in the year 1793, France, then groaning under the most intolerable and hideous tyranny, became engaged in war with almost all the governments of the civilized world, it is said to have been a matter of deliberation with the President of the United States, whether the republican envoy, or the agent of the French princes, should be received in America as the diplomatic representative of France. But whatever might be his private feelings of repugnance and horror, his public conduct was influenced only by his public duties. As a virtuous man he must have abhorred the system of crimes which was established in France. But as the first magistrate of the American commonwealth, he was bound only to consider how far the interest and safety of the people whom he governed were affected by the conduct of France. He saw that it was wise and necessary for America to preserve a good understanding and a beneficial intercourse with that great country, in whatever manner she was governed, as long as she abstained from committing injury against the United States. Guided by this just and simple principle, uninfluenced by the abhorrence of crimes which he felt, and which others affected, he received Mr Genet, the minister of the French Republic. The history of the outrages which that minister committed, or instigated, or countenanced, against the American government, must be fresh in the memory of all our readers. The conduct of Washington was a model of firm and dignified moderation. Insults were offered to his authority in official papers, in anonymous libels, by incendiary declaimers, and by tumultuous meetings. The law of nations was trampled under foot. His confidential ministers were seduced to betray him, and the deluded populace were so inflamed by the arts of their enemies, that they broke out into insurrection. No vexation, however galling, could disturb the tranquillity of his mind, or make him deviate from the policy which his situation prescribed. With a more confirmed authority, and at the head of a longer established government, he might perhaps have thought greater vigour justifiable. But in his circumstances, he was sensible that the nerves of authority were not strong enough to bear being strained. Persuasion, always the most desirable instrument of government, was in his case the safest. Yet he never overpassed the line which separates concession from meanness. He reached the utmost limits of moderation, without being betrayed into pusillanimity. He preserved external and internal peace by a system of mildness, without any of those virtual confessions of weakness, which so much dishonour and enfeeble supreme authority. During the whole of that arduous struggle, his personal character gave that strength to a *new magistracy* which in other countries arises from ancient habits of obedience and respect. The authority of his virtue was more efficacious for the preservation of America than the legal powers of his office.

During this turbulent period, he was re-elected to the office of the Presidency of the United States, which he held from April 1789 till September 1796. Probably no magistrate of any commonwealth, ancient or modern, ever occupied a place so painful and perilous. Certainly no man was ever called upon so often to sacrifice his virtuous feelings (he had no other sacrifices to make) to his public duty. Two circumstances of this sort deserve to be particularly noticed. In the spring of 1794, he sent an ambassador to Paris with credentials, addressed to his "Dear friends the citizens composing the Committee of Public Safety of the French Republic," whom he prays God "to take under his holy protection." Fortunately the American ambassador was spared the humiliation of presenting his credentials to these bloody tyrants. Their power was subverted, and a few of them had suffered the punishment of their crimes, which no punishment could expiate, before his arrival at Paris. Readily as we admit the purity of the motives which induced him to send this embassy to Paris, we cannot possibly approve of his conduct in deviating so far from the usual diplomatic style, as to call Robespierre his friend; but he was beset by an absurd, though formidable, faction at home.

He had another struggle of feeling and duty to encounter, when he was compelled to suppress the insurrection in the western counties of Pennsylvania by force of arms. But here he had a consolation. The exercise of mercy consoled his mind for the necessity of having recourse to arms. Never was there a revolt quelled with so little blood. Scarcely ever was the basest dastard so tender of his own life, as this virtuous man was of the lives of his follow-citizens. The value of his clemency is enhanced by recollecting that he was neither without provocations to severity, nor without pretexts for it. His character and his office had been reviled in a manner almost unexampled among civilized nations. His authority had been insulted.—His safety had been threatened. Of his personal and political enemies some might, perhaps, have been suspected of having instigated the insurrection; a greater number were thought to wish well to it; and very few shewed much zeal to suppress it. *Is habitus animorum fuit, ut pessimum facinus auderent pauci, plures vellent, omnes paterentur.* But neither resentment, nor fear, nor even policy itself, could extinguish the humanity of Washington. This seems to have been the only sacrifice which he was incapable of making to the interest of his country.

Throughout the whole course of his second Presidency, the danger of America was great and imminent almost beyond example. The spirit of change, indeed, at that period, shook all nations. But in other countries it had to encounter ancient and solidly established power; it had to tear up by the roots long habits of attachment in some nations for their government; of awe in others; of acquiescence and submission in all.—But in America the government was new and weak. The people had scarce time to recover from the ideas and feelings of a recent civil war. In other countries the volcanic force must be of power to blow up the mountains, and to convulse the continents that held it down,

down, before it could escape from the deep caverns in which it was imprisoned :—in America it was covered only by the ashes of a late convulsion, or at most by a little thin soil, the produce of a few years quiet.

The government of America had none of those salutary prejudices to employ, which in every other country were used with success to open the eyes of the people to the enormities of the French revolution. They had, on the contrary, to contend with the prejudices of their people in the most moderate precautions against internal confusion, in the most measured and guarded resistance to the unparalleled insults and enormous encroachments of France. Without zealous support from the people, the American government was impotent. It required a considerable time, and it cost an arduous and dubious struggle, to direct the popular spirit against a sister republic, established among a people to whose aid the Americans ascribed the establishment of their independence. It is probable, indeed, that no policy could have produced this effect, unless it had been powerfully aided by the crimes of the French government, which have proved the strongest allies of all established governments; which have produced such a general disposition to submit to any *known* tyranny, rather than rush into all the unknown and undefinable evils of civil confusion, with the horrible train of new and monstrous *tyrannies* of which it is usually the forerunner. But of these circumstances Washington availed himself with uncommon address. He employed the horror excited by the atrocities of the French revolution for the most honest and praise-worthy purposes; to preserve the internal quiet of his country; to assert the dignity, and to maintain the rights, of the commonwealth which he governed, against foreign enemies. He avoided war without incurring the imputation of pusillanimity. He cherished the detestation of Americans for anarchy, without weakening the spirit of liberty ; and he maintained, and even consolidated, the authority of government, without abridging the privileges of the people.

The resignation of Washington in 1796 was certainly a measure of prudence, and we doubt not of patriotism; but the conduct of his successor has been such as to give the Americans reason to regret that the reins of government were thrown up by the only hand, perhaps, that was fit to guide them during so unsettled a state of public affairs. When he retired, he published a valedictory address to his countrymen, as he had before done when he quitted the command of the army in 1783. In these compositions, the whole heart and soul of Washington are laid open. Other state papers have, doubtless, shewn more spirit and dignity, more eloquence, greater force of genius, and a more enlarged comprehension of mind ; but none ever displayed more simplicity and ingenuousness, more moderation and sobriety, more good sense, more prudence, more honesty, more earnest affection for his country and for mankind, more profound reverence for virtue and religion; more ardent wishes for the happiness of his fellow-creatures, and more just and rational views of the means which alone can effectually promote that happiness.

From his resignation till the month of July 1798, he lived in retirement at Mount Vernon. At this latter period, it became necessary for the United States to arm. They had endured with a patience, of which there is no example in the history of states, all the contumely and wrong which successive administrations in France had heaped upon them. Their ships were everywhere captured, their ministers were detained in a sort of imprisonment at Paris ; while incendiareis, clothed in the sacred character of ambassadors, scattered over their peaceful provinces the fire brands of sedition and civil war. An offer was made to terminate this long course of injustice, for a bribe to the French ministers. This offer was made by persons who *appeared* to be in the confidence of M. Talleyrand, who *professed* to act by his authority ; who have been since, indeed, disavowed by him ; but who never will be believed not to have been his agents, till he convict them of imposture by legal evidence, and procure them to be punished for so abominable a fraud.

The United States resolved to arm by land and sea. The command of the army was bestowed on General Washington ; which he accepted, because he was convinced that " every thing we hold dear and sacred was seriously threatened* ;" though he had flattered himself " that he had quitted for ever the boundless field of public action, incessant trouble and high responsibility, in which he had long acted so conspicuous a part." In this office he continued during the short period of his life which still remained.—On Thursday the 12th December 1799, he was seized with an inflammation in his throat, which became considerably worse the next day ; and of which, notwithstanding the efforts of his physicians, he died on Saturday the 14th of December 1799, in the 68th year of his age, and in the 23d year of the independence of the United States, of which he may be considered as the founder. The same calmness, simplicity, and regularity, which had uniformly marked his demeanor, did not forsake him in his dying moments. He saw the approaches of death without fear: —he met them without parade.—Even the perfectly well-ordered state of the most minute particulars of his private business, bore the stamp of that constant authority of prudence and practical reason over his actions, which was a distinguishing feature of his character. He died with those sentiments of piety which had given vigour and consistency to his virtue, and adorned every part of his illustrious life.

* See his *Letter of Acceptance.*

WATCHWORK. Our intention in this article does not extend to the manual practice of this art, nor even to all the parts of the machine. We mean to consider the most important and difficult part of the construction, namely, the method of applying the maintaining power of the wheels to the regulator of the motion, so as not to hurt its power of regulation. Our observations would have come with more propriety under the title SCAPEMENT, that being the name given by our artists to this part of the construction. Indeed they were intended for that article, which had been unaccountably omitted in the body of the Dictionary under the words CLOCK and WATCH. But the bad health and occupations of the person who had engaged to write the article, have obliged us to defer it to the last opportunity which the alphabetical arrangement affords us ; and, even now, the same causes unfortunately prevent the author from treating the subject in the manner he intended, and which it well deserves. But we trust that, from the account which is here given, the reader, who is conversant in mathematical philosophy, will perceive the justness of the conclusions, and that an intelligent

Watch-work.

gent artist will have no hesitation in acceding to the propriety of the maxims of construction deduced from them.

The regulator of a clock or watch is a pendulum or a balance. Without this check to the motion of the wheels, impelled by a weight or a spring, the machine would run down with a motion rapidly accelerating, till friction and the resistance of the air induced a sort of uniformity, as they do in a kitchen jack. But if a pendulum be so put in the way of this motion, that only one tooth of a wheel can pass it at each vibration, the revolution of the wheels will depend on the vibration of the pendulum. This has long been observed to have a certain constancy, insomuch that the astronomers of the East employed pendulums in measuring the times of their observations, patiently counting their vibrations during the phases of an eclipse or the transits of the stars, and renewing them by a little push with the finger when they became too small. Gassendi, Riccioli, and others, in more recent times, followed this example. The celebrated physician Sanctorius is the first person who is mentioned as having applied them as regulators of clock movements. Machines, however, called *clocks*, with a train of toothed wheels, leading round an index of hours, had been contrived long before. The earliest of which we have any account is that of Richard of Wallingford, Abbot of St Alban's, in 1326 (A). It appears to have been regulated by a fly like a kitchen jack*. Not long after this Giacomo Dondi made one at Padua, which had a *motus succussorius*, a hobbling or trotting motion; from which expression it seems probable that it was regulated by some alternate movement. We cannot think that this was a pendulum, because, once it was introduced, it never could have been supplanted by a balance. The alternate motion of a pendulum, and its seeming uniformity, are among the most familiar observations of common life; and it is surprising that they were not more early thought of for regulating time measurers. The alternate motions of the old balance is one of the most far-fetched means that can be imagined, and might pass for the invention of a very reflecting mind, while a pendulum only requires to be drawn aside from the plumb-line, to make it vibrate with regularity. The balance must be put in motion by the clock, and that motion must be stopped, and the contrary motion induced; and we must know that the same force and the same checks will produce uniform oscillations. All this must be previously known before we can think of it as a regulator; yet so it is that clocks, regulated by a balance, were long used, and very common through Europe, before Galileo proposed the pendulum, about the year 1600. Pendulum clocks then came into general use, and were found to be greatly preferable to balance clocks as accurate measurers of time. Mathematicians saw that their vibrations had some regular dependance on uniform gravity, and in their writings we meet with many attempts to determine the time and demonstrate the isochronism of the vibrations. It is amusing to read these attempts. We wonder at the awkwardness and insufficiency of the explanation given of the motions of pendulums, even by men of acknowledged eminence. Mersennus carried on a most useful correspondence with all the mathematicians of Europe, and was the means of making them acquainted with each other; nay, he was himself well conversant in the science; yet one cannot but smile at his reasonings on this subject. Standing on the shoulders of our predecessors, we look around us, in great satisfaction with our own powers of observation, not thinking how we are raised up, or that we are trading with the stock left us by the diligent and sagacious philosophers of the 17th century (B). Riccioli, Gassendus, and Galileo, made similar attempts to explain the motion of pendulums; but without success. This honour was reserved for Mr Huyghens, the most elegant of modern geometers. He had succeeded in 1656 or 1657 in adapting the machinery of a clock to the maintaining of the vibrations of a pendulum. Charmed with the accuracy of its performance, he began to investigate with scrupulous attention the theory of its motion. By the most ingenious and elegant application of geometry to mechanical problems, he demonstrated that the wider vibrations of a pendulum employed more time than the narrower, and that the time of a semicircular vibration is to that of a very small one nearly as 34 to 29; and, aided by a new department of geometrical science invented by himself, namely, the evolution of curves, he shewed how to make a pendulum swing in a cycloid, and that its vibrations in this curve are all performed in equal times, whatever be their extent.

* Conradi Gesneri Epitome, p. 604.

But before this time, Dr Hooke, the most ingenious and inventive mechanician of his age, had discovered the great accuracy of pendulum clocks, having found that the manner in which they had been employed had obscured their real merit. They had been made to vibrate in very large arches, the only motion that could be given them by the contrivances then known; and in 1656 he invented another method, and made a clock which moved with astonishing regularity. Using a heavy pendulum, and making it swing in very small arches, the clocks so constructed were found to excel Mr Huyghens's cycloidal pendulums; and those who were unfriendly to Huyghens had a sort of triumph on the occasion. But this was the result of ignorance. Mr Huyghens had shewn, that the error of $\frac{1}{100}$ of an inch, in the formation of the parts which produced the cycloidal motion, caused a greater irregularity of vibration than a circular vibration could do, although it should extend five or six degrees on each side of the perpendicular. It has been found that the unavoidable inaccuracies,

(A) Professor Beckmann, in the first volume of his *History of Inventions*, expresses a belief that clocks of this kind were used in some monasteries so early as the 11th century, and that they were derived to the monks from the Saracens. His authorities, however, are discordant, and seem not completely satisfactory even to himself.

(B) We are provoked to make this observation, by observing at this moment, in a literary journal, a pert and petulant upstart speaking of Newton's optical discoveries in terms of ridicule and abuse, employing these very discoveries to diminish his authority. Is it not thus that Christianity is now slighted by those who enjoy the fruits of the pure morality which it introduced?

Watch-work.

inaccuracies, even of the beſt artiſts, in the cycloidal conſtruction, make the performance much inferior to that of a common pendulum vibrating in arches which do not exceed three or four degrees from the perpendicular. Such clocks alone are now made, and they exceed all expectation.

We have ſaid that a pendulum needed only to be removed from the perpendicular, and then let go, in order to vibrate and meaſure time. Hence it might ſeem, that nothing is wanted but a machinery ſo connected with the pendulum as to keep a regiſter, as it were, of the vibration. It could not be difficult to contrive a method of doing this; but more is wanted. The air muſt be diſplaced by the pendulum. This requires ſome force, and muſt therefore employ ſome part of the momentum of the pendulum. The pivot on which it ſwings occaſions friction—the thread, or thin piece of metal by which it is hung, in order to avoid this friction, occaſions ſome expenditure of force by its want of perfect flexibility or elaſticity. Theſe, and other cauſes, make the vibrations grow more and more narrow by degrees, till at laſt the pendulum is brought to reſt. We muſt therefore have a contrivance in the wheelwork which will reſtore to the pendulum the ſmall portion of force which it loſes in every vibration. The action of the wheels therefore may be called a *maintaining power*, becauſe it keeps up the vibrations.

But we now ſee that this may affect the regularity of vibration. If it be ſuppoſed that the action of gravity renders all the vibrations iſochronous, we muſt grant that the additional impulſion by the wheels will deſtroy that iſochroniſm, unleſs it be ſo applied that the ſum-total of this impulſion and the force of gravity may vary ſo with the ſituation of the pendulum, as ſtill to give a ſeries of forces, or a law of variation, perfectly ſimilar to that of gravity. This cannot be effected, unleſs we know both the law which regulates the action of gravity, producing iſochroniſm of vibration, and the intenſity of the force to be derived from the wheels in every ſituation of the pendulum.

The neceſſary requiſite for the iſochronous motion of the pendulum is, that the force which urges it toward the perpendicular, be proportional to its diſtance from it (ſee DYNAMICS, nº 103. Cor. 7. *Suppl.*); and therefore, ſince pendulums ſwinging in ſmall circular arches are ſenſibly iſochronous, we muſt infer that ſuch is the law by which the accelerating action of gravity on them is really accommodated to every ſituation in thoſe arches.

It will greatly conduce to the better underſtanding of the effect of the maintaining power, if the reader keep in continual view the chief circumſtances of a motion of this kind. Therefore let AC a (fig. 1.) repre-
Plate XLVIII.
ſent the arch paſſed over by the pendulum, ſtretched out into a ſtraight line. Let C be its middle point, when the pendulum hangs perpendicular, and A and a be the extremities of the oſcillation. Let AD be drawn perpendicular to AC, to repreſent the accelerating action of gravity on the pendulum when it is at A. Draw the ſtraight line DC d, and $a\,d$, perpendicular to A a. About C, as a centre, deſcribe the ſemicircle AFH a. Through any points B, K, k, b, &c. of A a, draw the perpendiculars BFE, KLM, &c. cutting both the ſtraight line and the ſemicircle. Then,

1. The actions of gravity on the pendulum, when in the ſituations B, K, &c. by which it is urged toward C, are proportional to, and may be repreſented by, the ordinates BE, KL, $b\,e$, $k\,l$, &c. to the ſtraight line DC d.

2. The velocities acquired at B, K, &c. by the acceleration along AB, AK, &c. are proportional to the ordinates BF, KM, &c. to the ſemicircle AH a; and, therefore, the velocity with which the pendulum paſſes through the middle point C, is to its velocity in any other point B, as CH to BF.

3. The times of deſcribing the parts AB, BK, KC, &c. of the whole arch of oſcillation, are proportional to, and may be repreſented by, the arches AF, FM, MH, &c. of the ſemicircle.

4. If one pendulum deſcribe the arch repreſented by AC a, and another deſcribe the arch KC k, they will deſcribe them in equal times, and their maximum velocities (viz. their velocities in the middle point), are proportional to AC and KC; that is, the velocities in the middle point are proportional to the width of the oſcillations.

The ſame proportions are true with reſpect to the motions outwards from C. That is, when the pendulum deſcribes CA, with the initial velocity CH, its velocity at K is reduced to KM by the retarding action of gravity. It is reduced to BF at B, and to nothing at A; and the times of deſcribing CK, KB, BA, CA, are as HM, HF, HA. Another pendulum ſetting out from C, with the initial velocity CO, reaches only to K, CK being = CO. Alſo the times are equal.—If we conſider the whole oſcillation as performed in the direction A a, the forces AD, BE, KL accelerate the pendulum, and the ſimilar forces $a\,d$, $b\,e$, $k\,l$, on the other ſide, retard it. The contrary happens in the next oſcillation aCA.

5. The areas DABE, DAKL, &c. are proportional to the ſquares of the velocities acquired by moving along AB, AK, &c. or to the diminution of the ſquares of the velocities ſuſtained by moving outwards along BA or KA, &c.

The conſideration of this figure will enable the reader (even though not a mathematician) to form ſome notion of the effect of any propoſed application of a maintaining power by means of wheelwork: For, knowing the weight of the pendulum, we know the accelerating action of that weight in any particular ſituation A of the pendulum. We alſo know what addition or ſubtraction we produce on the pendulum in that ſituation by the wheel-work. Suppoſe it is an addition of preſſure equal to a certain number of grains. We can make AD to D δ as the firſt to the laſt; and then A δ will be the whole force urging the pendulum toward C. Doing the ſame for every point of AC, we obtain a line $\delta\,\iota\,\lambda\,c$, which is a new ſcale of forces, and the ſpace DC δ, comprehended between the two ſcales CD and C δ, will expreſs the addition made to the ſquare of the velocity in paſſing along AC by the joint action of gravity and the maintaining power. Alſo, by drawing a line $\kappa\,\pi$ perpendicular to AC, making the ſpace C $\pi\,\kappa$ equal to CAD, the point π will be the limit of the oſcillation outward from C, where the initial velocity HC is extinguiſhed. If the line $\kappa\,\pi$ cut the ſame circle in ϑ, one-half the arch ϑ A will nearly expreſs the contraction made in the time of the outward oſcillation by the maintaining power. An accurate determination

Watch-work. termination of this laſt circumſtance is operoſe, and even difficult; but this ſolution is not far from the truth, and will greatly aſſiſt our judgment of the effect of any propoſal, even though $\kappa \pi$ be drawn only by the judgement of the eye, making the area left out as nearly equal to the area taken in as we can eſtimate by inſpection. This is ſaid from experience.

Since the motion of a pendulum or balance is alternate, while the preſſure of the wheels is conſtantly in one direction, it is plain that ſome art muſt be uſed to accommodate the one to the other. When a tooth of the wheel has given the balance a motion in one direction, it muſt quit it, that it may get an impulſion in the oppoſite direction. The balance or pendulum thus eſcaping from the tooth of the wheel, or the tooth eſcaping from the balance, has given to the general contrivance the name of SCAPEMENT among our artiſts, from the French word *echappement*. We proceed, therefore, to conſider this ſubject more particularly, firſt conſidering the ſcapements which are peculiarly ſuited to the ſmall vibrations of pendulums, and then thoſe which muſt produce much wider vibrations in balances. This, with ſome other circumſtances, render the ſcapements for pendulums and balances very different.

I. *Of the Action of a Wheel and Pallet.*

THE ſcapement which has been in uſe for clocks and watches ever ſince their firſt appearance in Europe, is extremely ſimple, and its mode of operation is too obvious to need much explanation. In fig. 2. XY repreſents a horizontal axis, to which the pendulum P is attached by a ſlender rod, or otherwiſe. This axis has two leaves C and D attached to it, one near each end, and not in the ſame plane, but ſo that when the pendulum hangs perpendicularly, and at reſt, the piece C ſpreads a few degrees to the right hand, and D as much to the left. They commonly make an angle of 70, 80, or 90 degrees. Theſe two pieces are called PALLETS. AFB repreſents a wheel, turning round on a perpendicular axis EO, in the order of the letters AFEB. The teeth of this wheel are cut into the form of the teeth of a ſaw, leaning forward, in the direction of the motion of the rim. As they ſomewhat reſemble the points of an old-faſhioned royal diadem, this wheel has got the name of the CROWN WHEEL. In watches it is often called the *balance wheel*. The number of teeth is generally odd; ſo that when one of them B is preſſing on a pallet D, the oppoſite pallet C is in the ſpace between two teeth A and I. The figure repreſents the pendulum at the extremity of its excurſion to the right hand, the tooth A having juſt eſcaped from the pallet C, and the tooth B having juſt dropped on the pallet D. It is plain, that as the pendulum now moves over to the left, in the arch PG, the tooth B *continues* to preſs on the pallet D, and thus accelerates the pendulum, both during its deſcent along the arch PH, and its aſcent along the arch HG. It is no leſs evident, that when the pallet D, by turning round the axis XY, raiſes its point above the plane of the wheel, the tooth B eſcapes from it, and I drops on the pallet C, which is now nearly perpendicular. I preſſes C to the right, and accelerates the motion of the pendulum along the arch GP. Nothing can be more obvious than this action of the wheel in maintaining the vibrations of the pendulum. We can eaſily perceive, alſo, that when the pendulum is hanging perpendicularly in the line XH, the tooth B, by preſſing on the pallet D, will force the pendulum a little way to the left of the perpendicular, and will force it ſo much the farther as the pendulum is lighter; and, if it be ſufficiently light, it will be forced ſo far from the perpendicular that the tooth B will eſcape, and then I will catch on C, and force the pendulum back to P, where the whole operation will be repeated. The ſame effect will be produced in a more remarkable degree, if the rod of the pendulum be continued through the axis XY, and a ball Q put on the other end to balance P. And, indeed, this is the contrivance which was firſt applied to clocks all over Europe, before the application of the pendulum. They were balance clocks. The force of the wheel was of a certain magnitude, and therefore able, during its action on a pallet, to communicate a certain quantity of motion and velocity to the balls of the balance. When the tooth B eſcapes from the pallet D, the balls are then moving with a certain velocity and momentum. In this condition, the balance is checked by the tooth I catching on the pallet C. But it is not inſtantly ſtopped. It continues its motion a little to the left, and the pallet C forces the tooth I a little backward. But it *cannot* force it ſo far as to eſcape over the top of the tooth I; becauſe all the momentum of the balance was generated by the force of the tooth B; and the tooth I is equally powerful. Beſides, when I catches on C, and C continues its motion to the left, its lower point applies to the face of the tooth I, which now acts on the balance by a long and powerful lever, and ſoon ſtops its farther motion in that direction, and now, continuing to preſs on C, it urges the balance in the oppoſite direction.

Thus we ſee that in a ſcapement of this kind, the motion of the wheel muſt be very hobbling and unequal, making a great ſtep forward, and a ſhort ſtep backward, at every beat. This has occaſioned the contrivance to get the name of the RECOILING SCAPEMENT, the recoiling pallets. This hobbling motion is very obſervable in the wheel of an alarm.

Thus have we obtained two principles of regulation. The firſt and moſt obvious, as well as the moſt perfect, is the natural iſochronous vibration of a pendulum. The only uſe of the wheelwork here, beſides regiſtering the vibrations, is to give a gentle impulſion to the pendulum, by means of the pallet, in order to compenſate friction, &c. and thus maintain the vibrations in their primitive magnitude. But there is no ſuch native motion in a balance, to which the motion of the wheels muſt accommodate itſelf. The wheels, urged by a determined preſſure, and acting through a determined ſpace (the face of the pallet), muſt generate a certain determined velocity in the balance; and therefore the time of the oſcillation is alſo determined, both during the progreſſive and the retrograde motion of the wheel. The actions being ſimilar, and through equal ſpaces, in every oſcillation, they muſt employ the ſame time. Therefore a balance, moved in this manner, muſt be iſochronous, and a regulator for a time-keeper.

By thus employing a balance, the horizontal poſition of the axis XY is unneceſſary. Accordingly, the old clocks had this axis perpendicular, by which means the whole

whole weight of the balance refted on the point of the pivot Y or X, according as the balance PQ was placed above or below. By making the fupporting pivot of hard fteel, and very fharp, friction was greatly diminifhed. Nay, it was entirely removed from this part of the machine by fufpending the balance by a thread at the end X, inftead of allowing it to reft on the point of the pivot Y.

As the balance regulator of the motion admits of every pofition of the machine, thofe clocks were made in an infinite variety of fanciful forms, efpecially in Germany, a country famous for mechanical contrivances. They were made of all fizes, from that of a great fteeple clock, to that of an ornament for a lady's toilet. The fubftitution of a fpring in place of a weight, as a firft mover of the wheel-work, was a moft ingenious thought. It was very gradual. We have feen, in the Emperor's mufeum at Bruffels, an old (perhaps the firft) fpring clock, the fpring of which was an old fword blade, from the point of which a catgut was wound round the barrel of the firft wheel. Some ingenious German fubftituted the fpiral fpring, which both took lefs room, and produced more revolutions of the firft wheel.

When clocks had been reduced to fuch fmall fizes, the wifh to make them portable was very natural; and the means of accomplifhing this were obvious, namely, a farther reduction of their fize. This was accomplifhed very early; and thus we obtained pocket watches, moved by a fpiral fpring, and regulated by a balance with the recoiling fcapement, which is ftill in ufe for common watches. The hobbling motion of the crown wheel is very eafily feen in all of them.

It is very uncertain who firft fubftituted a pendulum in place of the balance (Clock, *Encycl.*) Huyghens, as we have already obferved, was the firft who inveftigated the motions of pendulums with fuccefs, and his book *De Horologio Ofcillatorio* may be confidered as the elements of refined mechanics, and the fource of all the improvements that have been made in the conftruction of fcapements. But it is certain that Dr Hooke had employed a pendulum for the regulation of a clock many years before the publication of the abovementioned treatife, and he claims the merit of the invention of the *only proper* method of employing it. We imagine therefore that Dr Hooke's invention was nothing more than a fcapement for a pendulum making fmall vibrations, without making ufe of the oppofite motions of the two fides of the crown wheel. Dr Hooke had contrived fome fcapement more proper for pendulums than the recoiling pallets, becaufe certainly thofe might be employed, and are actually employed as a fcapement for pendulum clocks to this day, although they are indeed very ill adapted to the purpofe. He had not only remarked the great fuperiority of fuch pendulum clocks as were made before Huyghens's publication of the cycloidal pendulum over the balance clocks, but had alfo feen their defects, arifing from the light pendulums and wide arches of vibration, and invented a fcapement of the nature of thofe now employed. The pendulum clock which he made in 1658 for Dr Wilkins, afterwards Bifhop of Chefter, is mentioned by the inventor as peculiarly fuited to the moderate fwing of a pendulum; and he oppofes this circumftance to a general practice of wide vibrations and trifling pendulums. The French are not in the practice of afcribing to us any thing that they can claim as their own; yet Lepaute fays that the *Echappement à l'Ancre* came from England about the year 1665. It is alfo admitted by him that clock-making flourifhed in England at that time, and that the French artifts went to London to improve in it. Putting thefe and other circumftances together, we think it highly probable that we are indebted to Dr Hooke for the fcapement now in ufe. The principle of this is altogether different from the fimple pallets and direct impulfe already defcribed; and is fo far from being obvious, that the manner of action has been mifunderftood, even by men of fcience, and writers of fyftems of mechanics.

In this fcapement we employ thofe teeth of the wheel which are moving in one direction; whereas in the former fcapement, oppofite teeth were employed moving in contrary directions. Yet even here we muft communicate an alternate motion to the axis of the pallets. The contrivance, in general, was as follows: On the axis A (See fig. 3.) of the pendulum or balance is fixed a piece of metal BAC, called the crutch by our artifts, and the anchor by the French. It terminates in two faces B *b* C *c* of tempered fteel, or of fome hard ftone. Thefe are called the pallets, and it is on them that the teeth of the wheel act. The faces B *b* C *c* are fet in fuch pofitions that the teeth pufh them out of the way. Thus B pufhes the pallet to the left, and C pufhes its pallet to the right. Both pufh their pallets fidewife outward from the centre of the wheel. The pallet B is ufually called the *leading*, and C the *driving* pallet by the artifts, although it appears to us that thefe names fhould be reverfed, becaufe B *drives* the pallet out of the way, and C *pulls* or leads it out of the way. They might be called the *firft* and *fecond* pallet, in the order in which they are acted on by the wheel. We fhall ufe either denomination. The figure is accommodated to the inactive or refting pofition of the pendulum. Suppofe the pendulum drawn afide to the right at Q, and then let go. It is plain that the tooth B, preffing on the face of the pallet β B *b* all the way from β to *b*, thrufts it afide outwards, and thus, by the connection of the crutch with the pendulum rod, aids the pendulum's motion along the arch QPR. When the pendulum reaches R, the point of the tooth B has reached the angle *b* of the pallet, and efcapes from it. The wheel preffing forward, another tooth C drops on the pallet face C *c*, and, by preffing this pallet outward, evidently aids the pendulum in its motion from R to P. The tooth C efcapes from this pallet at the angle *c*, and now a tooth B′ drops on the firft pallet, and again aids the pendulum; and this operation is repeated continually.

The mechanifm of this communication of motion is thus explained by feveral writers of elements. The tooth B (fig. 2.) is urged forward in the direction BD, perpendicular to the radius MB of the swing wheel. It therefore preffes on the pallet, which is moveable only in the direction BE, perpendicular to BA the radius of the pallet. Therefore the force BD muft be refolved into two, *viz.* BE, in the direction in which alone the pallet can move, and ED, or BF, perpendicular to that direction. The laft of thefe only preffes the pallet and crutch againft the pivot hole A.

BE

BE is the only useful force, or the force communicated to the pallet, enabling it to maintain the pendulum's motion, by restoring the momentum lost by friction and other causes.

But this is a very erroneous account of the *modus operandi*, as may be seen at once, by supposing the radius of the pallets to be a tangent to the wheel. This is a position most frequently given to them, and is the very position in fig. 3. In this case MB is perpendicular to BA, and therefore BD will coincide with BA, and there will be no such force as BE to move the pendulum. It is a truth, deducible from what we know of the mechanical constitution of solid bodies, and confirmed by numberless observations, that when two solid bodies press on each other, either in impulsion or in dead pressure, the direction in which the mutual pressure is exerted is always perpendicular to the touching surfaces, whatever has been the direction of the impelling body (See Impulsion, *Suppl.* n° 66. Machinery, *Suppl.* n° 35. and several other parts of this Work.) Moreover this pressure is mutual, equal, and opposite. Whatever be the shapes of the faces of the tooth and pallet, we can draw a plane BN, which is the common tangent to both surfaces, and a line HBI through the point of contact perpendicular to BN. It is farther demonstrated in the article Machinery, *Suppl.* n° 35, &c. that the action of the wheel on the pendulum is the same as if the whole crutch were annihilated, and in its stead there were two rigid lines AH, MI, from the centres of the crutch and wheel, perpendicular to HI, and connected by a third rigid line or rod HI, touching the two in H and I.

For if a weight V be hung at v, the extremity of the horizontal radius M v of the wheel, it will act on the lever v MI, pressing its point I upwards in the direction IH perpendicular to MI; the upper end of this rod IH will, in like manner, press the extremity H of the rod HA, and this will urge the pendulum from P toward R. To withstand this, the pendulum rod AP may be withheld by a weight z, hanging by a thread on the extremity of the horizontal lever A z, equal to M v, and connected with the crutch and pendulum. The weights V and z may be so proportioned to each other that, by acting perpendicularly on the crooked levers v MI, and z AH, the pressures at H and I shall be equal, and just balance each other by the intervention of the rod HI. When this is the case, we have put things into the same mechanical state, in respect of mutual action, as is effected by the crutch, pallets, and wheel, which, in like manner, produce equal pressures at B the point of contact, in the direction BH and BI. The weight V may be such as produces the very same effect at B that is produced by the previous train of wheel-work. The weight z therefore must be just equal to the force produced by the wheel-work on the point z of the pendulum rod, because by acting in the opposite direction it just balances it. Let us see therefore what force is communicated to the pendulum by the wheels.

Let x be the upward pressure excited at I, and y the equal opposite pressure excited at H. Then, by the property of the lever, we have $\text{MI} : \text{M}v = \text{V} : x$, and $x \times \text{MI} = \text{V} \times \text{M}v$. In like manner $y \times \text{AH} = \text{Z} \times \text{A}z$. Therefore, because $x = y$, and $\text{A}z = \text{M}v$, we have $\text{V} : \text{Z} = \text{MI} : \text{AH}$. That is, the force exerted by the tooth of the wheel in the direction of its motion is to the force impressed on the pendulum rod at a distance equal to the radius of the wheel as MI to AH. The force impressed on the ball of the pendulum is less than this in the proportion of AP to A z, or M v.

Cor. 1. If the perpendiculars MN, AV, be drawn on the tangent plane, the forces at B and z will be as BN to BO. For these lines are respectively equal to MI and AH.

Cor. 2. If HI meet the line of the centres AC in S, the forces will be as SM to SA; that is, $\text{V} : \text{Z} = \text{SM} : \text{SA}$.

Cor. 3. If the face β B b of the pallet be the evolutrix of a circle described with the radius AH, and the face of the tooth be the evolutrix of a circle described with the radius MI, the force impressed on the pendulum by the wheels will be constant during the whole vibration (Machinery, n° 36.) But these are not the only forms which produce this constancy. The forms of teeth described by different authors, such as De la Hire, Camus, &c. for producing a constant force in trains of wheel work, will have the same effect here. It is also easy to see that the force impressed on the pendulum may be varied according to any law, by making these faces of a proper form. Therefore the face, from B outwards, may be so formed that the force communicated to the pendulum by the wheels, during its descent from Q to P, may be in one constant proportion to the acceleration of gravity, and then the sum of the forces will be such as produce isochronous vibrations. If the inner part B b of the face be formed on the same principle, the difference of the forces will have the same law of variation. If the face βb be the evolutrix of a circle, and the tooth B terminate in a point gently rounded, or quite angular, the force on the pendulum will continually increase as the tooth slides from β to b. For the line AH continues of the same magnitude, and MI diminishes. The contrary will happen, if the pallet be a point, either sharp or rounded, and if the face of the tooth be the evolutrix now mentioned; for MI will remain the same, while AH diminishes. If the tooth be pointed, and βb be a straight line, the force communicated to the pendulum will diminish, while the tooth slides from β to b. For in this case AH diminishes and MI increases.

Cor. 4. In general, the force on the pendulum is greater as the angle MB b increases, and as AB b diminishes.

Cor. 5. The angular velocity of the wheel is to that of the pendulum, in any part of its vibration, as AH to MI. This is evident, because the rod IH moving (in the moment under consideration) in its own direction, the points H and I move through equal spaces, and therefore the angles at A and M must be inversely as the radii.

All that has now been said of the first pallet AB may be applied to the second pallet AC.

If the perpendiculars C s be drawn to the touching plane o C n, cutting AM in s, we shall have $\text{V} : z = s\text{M} : s\text{A}$, as in Cor. 2. And if the perpendiculars Mi, Ah, be drawn on C s, we have $\text{V} : \text{Z} = \text{M}i : \text{A}h$, as in the general theorem. The only difference between the action on the two pallets is, that if the faces of both are plain, the force on the pendulum increases during the whole of the action on the pallet C, whereas it dimi-

 nishes

nifhes during the progrefs of the tooth along the other pallet.

The reader will doubtlefs remark that each tooth of the wheel acts on both pallets in fucceffion ; and that, during its action on either of them, the pendulum makes one vibration. Therefore the number of vibrations during one turn of the wheel is double the number of the teeth : confequently, while the tooth flides along one of the pallets, it advances half the fpace between two fucceffive teeth ; and when it efcapes from the pallet, the other tooth *may* be juft in contact with the other pallet. We fay it *may* be fo ; in which cafe there will be no dropping of the teeth from pallet to pallet. This, however, requires very nice workmanfhip, and that every tooth be at precifely the fame diftance from its neighbour. Should the tooth which is juft going to apply to a pallet chance to be a little too far advanced on the wheel, it would touch the pallet before the other had efcaped. Thus, fuppofe that before B efcapes from the point b of the pallet, the tooth C is in contact with the pallet CG, B cannot efcape. Therefore when the pendulum returns from R towards Q, the pallet βb, returning along with it, will pufh back the tooth B of the wheel. It does this in oppofition to the force of the wheel. Therefore, whatever motion the wheel had communicated to the pendulum, during its fwing from P to Q, will now be taken from it again. The pendulum will not reach Q, becaufe it had been aided in its motion from Q, and had proceeded further than it would have done without this help. Its motion toward Q is further diminifhed by the friction of the pallet. Therefore it will now return again from fome nearer point q, and will not go fo far as in the laft vibration, but will return through a ftill fhorter arch : And this will be ftill more contracted in the next vibration, &c. &c. Thus it appears that if a tooth chances to touch the pallet before the efcape of the other, the wheel will advance no farther, and foon after the pendulum will be brought to reft.

For fuch reafons it is neceffary to allow one tooth to efcape *a little before* the other reaches the pallet on which it is to act, and to allow a fmall drop of the teeth from pallet to pallet. But it is accounted bad workmanfhip to let the drop be confiderable, and *clofe fcapement* is accounted a mark of care and of good workmanfhip. It is evidently an advantage, becaufe it gives a longer time of action on each pallet. This freeing the fcapement cannot be accomplifhed by filing fomething from the face of the tooth ; becaufe this being done to all, the diftance between them is diminifhed rather than augmented. The pallets muft be firft fcaped as clofe as poffible. This obliges the workman to be careful in making the teeth equidiftant. Then a fmall matter is taken from the point of each pallet, by filing off the back $b\,r$ of the pallet. The tooth will now efcape before it has moved through half a fpace.

From all that has been faid on this particular, it appears that the interval between the pallets muft comprehend a certain number of teeth, and half a fpace more.

The firft circumftance to be confidered in contriving a fcapement is the angular motion that is intended to be given to the pendulum during the action of the wheel. This is ufually called the *angle of fcapement*, or the *angle of action*. Having fixed on an angle a that we think proper, we muft fecure it by the pofition and form of the face of the pallets. Knowing the number of teeth in the fwing-wheel, divide 180° by this number, and the quotient is the angle b of the wheel's motion during one vibration of the pendulum. In the line AM, joining the centres of the crutch and wheel, make SM to SA, and sM to sA, as the angle a to the angle b; and then, having determined how many teeth fhall be comprehended between the pallets, call this number n. Multiply the angle b by $n + 1$, and take the half of the product. Set off this half in the circumference of the wheel (at the points of the teeth) on each fide of the line joining the centres of the crutch and wheel, as at TB and TC. Through S and s draw SB and sC, and through B draw βBb perpendicular to SB, for the medium pofition of the face of the firft pallet ; that is, for its pofition when the pendulum hangs perpendicular. In like manner, drawing oCn perpendicular to sC, we have the medium pofition of the fecond pallet. The demonftration of this conftruction is very evident from what has been faid.

We have hitherto fuppofed that the pendulum finifhes its vibration at the inftant that a tooth of the wheel efcapes from a pallet, and another tooth drops on the other pallet. But this is never, or fhould never be, the cafe. The pendulum is made to fwing fomewhat beyond the angle of fcapement : for if it do not when the clock is clean and in good order, but ftop precifely at the drop of a tooth, then, when it grows foul, and the vibration diminifhes, the teeth will not efcape at all, and the clock will immediately ftop. Therefore the force communicated by the wheels during the vibration within the limits of fcapement, muft be increafed fo as to make the pendulum *throw* (as the artifts term it) farther out; and a clock is more valued when it throws out confiderably beyond the angle of fcapement. There are good reafons for this. The momentum of the pendulum, and its power to regulate the clock (which Mr Harrifon fignificantly called its *dominion*), is proportional to the width of its vibrations very nearly.

This circumftance of exceeding the angle of fcapement has a very great influence on the performance of the clock, or greatly affects the dominion of the pendulum. It is eafy to fee that, when the face βb of the leading pallet is a plane, if the pendulum continue its motion to the right, from P toward Q, after the tooth B has dropped on it, the pallet will pufh the wheel back again, while the tooth flides outward on the pallet toward β. Such pallets therefore will make a *recoiling fcapement*, refembling, in this circumftance, the old pallet employed with the crown wheel, and will have the properties attached to this circumftance. One confequence of this is, that it is much affected by any inequalities of the maintaining power. It is a matter of the moft familiar obfervation, that a common watch goes flower when within a quarter of an hour of being down, when the action of the fpring is very weak, in confequence of its not pulling by a radius of the fufee. We obferve the fame thing in the beating of an alarum clock. Alfo if we at any time prefs forward the wheelwork of a common watch with the key, we obferve its beats accelerate immediately. The reafon of this is pretty plain. The balance, in confequence of the acceleration in the angle of fcapement, would have gone much farther, employing a confiderable time in the

Watch-work.

the excurſion. This is checked abruptly, which both ſhortens the vibration and the time employed in it. In the return of the pendulum, the motion is accelerated the whole way, along an arch which is ſhorter than what correſponds to its velocity in the middle point; for it is again checked on the other ſide, and does not make its full excurſion. Moreover, all this irregularity of force, or the great deviation from a reſiſtance to the excurſion proportional to the diſtance from the middle point, is exerted on the pendulum when it is near the end of the excurſion, where the velocity being ſmall, this irregular force acts long upon it, at the very time that it has little force wherewith to reſiſt it. All temporary inequalities of force, therefore, will be more felt in this ſituation of the balance than if they had been exerted in the middle of its motion. And although the regulating power of a pendulum greatly exceeds that of the light balances uſed in pocket watches, ſomething of the ſame kind may be expected even in pendulum clocks. Accordingly this appears by a ſeries of experiments made by Mr Berthoud, a celebrated watchmaker of Paris. A clock, with a half ſecond pendulum weighing five drams, was furniſhed with a recoiling ſcapement, whoſe pallets were planes. The angle of ſcapement was $5\frac{1}{2}$ degrees. When actuated with a weight of two pounds, it ſwung 8°, and loſt 15′ per hour; with four pounds, it ſwung 10°, and loſt 6′. Thus it appears that by doubling the maintaining power, although the vibration was increaſed in conſequence of the greater impulſe, the time was leſſened 9″ per hour, viz. about $\frac{1}{400}$. It is plain, from what was ſaid when we deſcribed the firſt ſcapement, that an increaſe of maintaining power muſt render the vibration more frequent. We ſaw, on that occaſion, that, even when the gravity of the pendulum is balanced by a weight on the other end of the rod, the force of the wheels will produce a vibratory motion, and that an augmentation of this force will increaſe it, or make the vibrations more rapid. The preciſe effect of any particular form of teeth can be learned only by computing the force on the pendulum in every poſition, and then conſtructing the curve ʃ ε λ C of fig. 1. The rapid increaſe of the ordinates beyond thoſe of the triangle ADC, forms a conſiderable area DA π o, to compenſate the area π o C, and thus makes a conſiderable contraction A π of the vibration, and a ſenſible contraction $\frac{A\theta}{2}$ of the time.

Mr George Graham, the celebrated watchmaker in London, was alſo a good mathematician, and well qualified to conſider this ſubject ſcientifically. He contrived a ſcapement, which he hoped would leave the pendulum almoſt in its natural ſtate. The acting face of the pallet *a b c* (fig. 4.) is a plane. The tooth drops on *a*, and eſcapes from *c*, and is on the middle point *b* when the pendulum is perpendicular. Beyond *a*, the face of the pallet is an arch *a d*, whoſe centre is A, the centre of the crutch. The maintaining power is made ſo great as to produce a much greater vibration than the angle of active ſcapement *a* A *c*. The conſequence of this is that, when the tooth drops on the angle *a*, the pendulum, continuing its motion, carries the crutch along with it, and the tooth paſſes on the arch *a d*, in a direction paſſing through the centre of the crutch. This preſſure can neither accelerate nor retard the motion of the crutch and pendulum. As the pendulum was accelerated after it paſſed the perpendicular, by the other pallet, it will (if quite unobſtructed) throw out farther than what correſponds to the velocity which it had in the middle point of its vibration; perhaps till the tooth paſſes from *a* to *e* on the circular arch of the pallet. But although it ſuſtains no contrary action from the wheels during this excurſion beyond the angle of ſcapement, it will not proceed ſo far, but will ſtop when the tooth reaches *d*; becauſe there muſt be ſome reſiſtance ariſing from the friction of the tooth along the arch *a d*, and from the clammineſs of the oil employed to lubricate it: but this reſiſtance is exceedingly minute, not amounting to $\frac{1}{8}$th of the preſſure on the arch. Nay, we think that it appears from the experiments of Mr Coulomb that, in the caſe of ſuch minute preſſures on a ſurface covered with oil, there is no ſenſible retardation analogous to that produced by friction, and that what retardation we obſerve ariſes entirely from the clammineſs of the oil. We are ſo imperfectly acquainted with the manner in which friction and viſcidity obſtruct the motions of bodies, that we cannot pronounce deciſively what will be their effect in the preſent caſe. Friction does not increaſe much, if at all, by an increaſe of velocity, and appears like a fixed quantity when the preſſure is given. This makes all motions which are obſtructed by friction terminate abruptly. This will ſhorten both the length and the time of the outward excurſion of the pendulum. The viſcidity of the oil reſiſts differently, and more nearly in the proportion of the velocities. The diminution of motion will not be in this proportion, becauſe in the greater velocities it acts for a ſhorter time. Were this accurately the caſe, the reſiſtance of viſcidity would alſo be nearly conſtant, and it would operate as friction does. But it does not ſtop a motion abruptly, and the motions are extinguiſhed gradually. Therefore, although viſcidity muſt always diminiſh the extent of the excurſion, it may ſo vary as not to diminiſh the time. We apprehend, however, that it generally does. But whatever happens in the excurſion, the return will certainly be ſlower, and employ more time than if it had not been obſtructed, becauſe the velocity in every point is leſs than if perfectly free. The whole arch, conſiſting of a returning arch and an excurſion on the other ſide, may be either ſlower or quicker, according as the compenſation is complete or not, or is even overdone.

All theſe reflections occurred to Mr Graham; and he was perſuaded that the time of the tooth's remaining on the arch *a d*, both aſcending and deſcending, would differ very little from that of the deſcription of the ſame arch by a free pendulum. The great cauſes of irregularity ſeemed to be removed, viz. the inequalities in the action of the wheels in the vicinity of the extremity of the vibration, where the pendulum having little momentum is, long in the ſame little ſpace, expoſed to their action. The derangement produced by any force depends on the time of its action, and therefore muſt be greateſt when the motion is ſloweſt. The pendulum gets its impulſe in the very middle of its vibration, where its velocity is the greateſt; and therefore the inequalities of the maintaining power act on it only for a ſhort time, and make a very trifling alteration in the time of its deſcribing the arch of ſcapement. Beyond this, it is nearly in the ſtate of a free pendulum;

lum ; nay, even though it be affected by an inequality of the maintaining power, and it be accelerated beyond its usual rate in that arch, the chief effect of this will be to cause it to describe a larger arch of excursion. The shortening of the time of this description by the friction will be the same as before, happening at the very end of the excursion ; but the return will be more retarded by the friction on a longer arch. And, by this, a compensation may be made for the trifling contraction of the time of describing the arch of scapement.

This circumstance of giving the impulse in the middle of the vibration. where its time of action is the smallest possible, and whereby the pendulum is so long left free from the action of the wheels, is of the very first importance in all scapements, and should ever be in the mind of the mechanician. When this is adhered to, the form of the face *a b c* is scarcely of any moment. Much has been written on this form, and many attempts have been made to make it such that the action of the wheels shall be proportional to the action of gravity. To do this is absolutely impossible. Mr Graham made them planes, not only because of easiest execution, but because a plane really conspires pretty well with the change of gravity. While the pendulum moves from Q to P (fig. 3.), the force of gravity, acting in the direction QP, is continually diminishing. So is the accelerating power of the pallet from *a* to *b*. When the pendulum rises from P to R, a force in the opposite direction RP continually increases. This is analogous to the continual diminution of a force in the direction PR. Now we have such a diminution of such a force, in the action of the pallet from *b* to *c*, and such an augmentation in the action of the other pallet.

For all these reasons, this construction of a scapement appeared very promising. Mr Graham put it in practice, and it answered his most sanguine expectation, and is now universally adopted in all nice clocks. Mr Graham, however, did not think it prudent to cause a tooth to drop on the very angle *a* of the pallet. He made it drop on a point *f* of the arch of excursion. This has also the advantage of diminishing the angle of action, which we have proved to be of service. It requires, indeed, a greater maintaining power ; but this can easily be procured, and is less affected by the changes to which it is liable by the effect of heat and cold on the oil. Our observations on the effects of friction and viscidity in the arch *a d* seem to be confirmed by the observations of several artists, who agree in saying that a great increase of maintaining power increases the vibrations, but makes them perceptibly slower. When they wrote, much oil was applied to diminish the friction on the arch of repose ; but, since that time, the rubbing parts were made such as required no oil, and this retardation disappeared. In the clock of the transit room of the Royal Observatory, the angle of action seldom exceeds one-third of the swing of the pendulum. The pallets are of oriental ruby, and the wheel is of steel tempered to the utmost degree of hardness. This clock never varies a whole second from equable motion in the course of five days.

This contrivance is known by the name of the DEAD BEAT, the DEAD SCAPEMENT; because the seconds index stands still after each drop, whereas the index of a clock with a recoiling scapement is always in motion, hobbling backward and forward.

These scapements, both recoiling and dead beat, have been made in a thousand forms ; but any person tolerably acquainted with mechanics, will see that they are all on the same principles, and differ only in shape or some equally unimportant circumstance. Perhaps the most convenient of any is that represented in fig. 5. where the shaded part is the crutch, made of brass or iron, and A and B are two pieces of agate, flint, or other hard stone, cut into the proper shape for a pallet of either kind, and firmly fixed in proper sockets. They project half an inch, or thereabouts, in front of the crutch, so that the swing wheel is also before the crutch, distant about $\frac{1}{10}$th of an inch or so. Pallets of ruby, driven by a hard steel swing wheel, need no oil, but merely to be once rubbed clean with an oily cloth.

Sometimes the wheel has pins instead of teeth. They are ranged round the rim of the wheel, perpendicular to its plane, and both pallets are on one side of the wheel, standing perpendicular to its plane. One of these pins drops from the first to the second pallet at once. The pallets are placed on two arms, as in fig. 6. in which case the pins are alternately on different sides of the wheel ; or on one, as in fig. 7. By the motion of the pendulum to the right, the pin (in fig. 7.), after resting on the concave arch *d a*, acts on the face *a c*, and drops from *c* on the other concave arch *i g*, which continues to move a little way to the right. It then returns, and the pin slides and acts on the pallet *i h*, and escapes at *h* ; and the next pin is then on the arch of repose *d a*.

It being evident that the recoiling scapement accelerates the vibrations beyond the rate of a free pendulum, and it also appearing to many of the first artists that the dead scapement retards them, they have attempted to form a scapement which shall avoid both of these defects, by forming the arches *a d*, *i g*, so as to produce a very small recoil. Mr Berthoud does this in a very simple manner, by placing the centre of *a d* at a small distance from that of the crutch, so as to make the rise of the pallet above the concentric arch about one-third of the arch itself. Applying such a crutch to the light pendulum mentioned in a former paragraph, he found that doubling, and even trebling the maintaining power, produced no change in the time of vibration, though it increased the width from 8° to 12° and 14°. We have no doubt of the efficacy of this contrivance, and think it very proper for all clocks which require much oil, such as turret clocks, &c. But we apprehend that no rule can be given for the angle that the recoiling arch should make with the concentric one. We imagine that this depends entirely on the share which friction and oil have in producing the retardation of the dead beat.

Other artists have endeavoured to avoid the inconveniences of friction and oil on the arch of repose in another way. Instead of allowing the tooth of the wheel to drop on the back of the pallet, which we called the *arch of excursion*, and others call the *arch of repose*, it drops on a detent *o t a* (fig. 8.), of which the part *t a* is part of an arch whose centre is A, the centre of the crutch, and the part *t o* is in the direction of the radius. This piece does not adhere to the pallet, but is on the end of an arm *o* A, which turns round the axis A of the crutch on fine pivots : it is made to apply itself to the back of the pallet by means of a slender spring A*p*, attached to the pallet, and pressing inward on a pin *p*, fixed

fixed in the arm of the detent. When fo applied, its arch *t a* makes the repofe, and its point *a* makes a fmall portion of the face *a c* of the pallet.

The action of this apparatus is very eafily underftood. When a tooth efcapes from the fecond pallet, by the motion of the pendulum from the left to the right, another tooth drops on this pallet (which the figure fhews to be the firft or leading pallet) at the angle *t*, and refts on the fmall portion *t a* of an arch of repofe. But the crutch, continuing its motion to the right, immediately quits the arm *o A*, carrying the pallet *a c r* along with it, and leaving the wheel locked on the detent *o t a*. By and bye the pendulum finifhes its excurfion to the right, and returns. When it enters the arch of action, the pallet has applied itfelf to the detent *o t a*, and withdraws it from the tooth. The tooth immediately acts on the face *a c* of the pallet, and reftores the motion loft during the laft vibration. The ufe of the fpring is merely to keep the detent applied to the pallet without fhaking. It is a little bent during their feparation, and adds fomething of an oppofing force to the afcent of the pendulum on the other fide of the wheel, and accelerates its return. A fimilar detent on the back of the fecond pallet performs a fimilar office, fupporting the wheel while the pendulum is beyond the arch of fcapement, and quitting it when the pendulum enters that arch.

We do not know who firft practifed this very ingenious and promifing invention. Mr Mudge certainly did fo as early as 1753 or 1754. Mr Berthoud fpeaks obfcurely of contrivances of the fame nature. So does Le Roy, and (we think) Le Paute. We fay that it is very promifing. Friction is almoft annihilated by transferring it to the pivots at A; fo that, in the excurfion beyond the angle of fcapement, the pendulum feems almoft free. Indeed fome artifts of our acquaintance have even avoided the friction of the pivots at A, by making the arm of the detent a fpring of confiderable thicknefs, except very near to A, where it is made very thin and broad. But we do not find that this conftruction, though eafily executed, and fufceptible of great precifion and fteadinefs of action, is much practifed. We prefume that the performance has not anfwered expectations. It has not been fuperior to the incomparably more fimple dead fcapement of Graham. Indeed we think that it cannot. A part of the friction ftill remains, which cannot be removed; namely, while the arch *t a* is drawn from between the tooth and pallet. Nay, we apprehend that fomething more than friction muft be overcome here. The tooth is apt to force the detent outward, unlefs the part *t a* be a little elevated at its point *a* like a claw, above the concentric arch, and the face of the tooth be made to incline forward, fo as to fit this fhape of the detent. This will confume fome force, when the momentum of the pendulum is by no means at its maximum. Should the clock be foul, and the excurfions beyond fcapement be very fmall, this difturbance muft be exceedingly pernicious. But we have a much greater objection. During the whole excurfion beyond fcapement, there is a new force of a fpring acting on the pendulum, which deviates confiderably from the proportions of the accelerating power of gravity. It does not commence its action till the detent feparates from the arm of the crutch. Then the fpring of the detent acts as a retarding force againft the excurfion of the pendulum, now on the other fide, bringing it fooner to reft, and then accelerating it in its way back to the beginning of the arch of fcapement. In fhort, this conftruction fhould have the properties of a recoiling fcapement. We got a clock-maker to make fome experiments on one which he had made for an amateur, which fully confirmed our conjecture. When the detent fpring was ftrong, an increafe of maintaining power made the vibrations both wider and more rapid. The artift reduced the ftrength of the fpring till this effect was rendered very fmall. It might perhaps be quite removed by means of a ftill weaker fpring: But the fpring was already fo weak that a hard ftep on the floor of the room did fometimes difengage the detent from the wheel. It appears, therefore, that nothing can be reafonably expected from this conftruction that is not as well performed by the dead fcapement of Mr Graham, of much eafier execution, and more certain performance.

Very fimilar to this conftruction (at leaft in the excurfion beyond the angle of fcapement) is the conftruction of Mr Cumming, and it has the fame defects. His pallets are carried, as in the one defcribed, by the crutch. The detents prefs on them behind by their weight only: therefore, when the tooth is locked on the detent of one pallet, its weight is taken off from the pendulum on that fide, and the weight of the detent on the other fide oppofes the afcent, and accelerates the defcent of the pendulum.

Mr Cumming executed another fcapement, confifting, like thofe, of a pallet and detent. But the manner of applying the maintaining power is extremely different in principle from any yet defcribed. It is exceedingly ingenious, and feems to do all that is poffible for removing every fource of irregularity in the maintaining power, and every obftruction to free motion arifing from friction and oil in the fcapement. For this reafon we fhall give fuch an account of its effential circumftances as may fuffice to give a clear conception of its manner of acting, and its good properties and defects; but referring the inquifitive reader to Mr Cumming's Elements of Clock and Watch Work, publifhed in 1766, for a more full account.

In the fcapements laft defcribed, the pallets were fixed to the crutch and pendulum, and the maintaining power, during its action, was applied to the pendulum by means of the pallets, in the fame way as in ordinary fcapements. The detents were unconnected with the pendulum, and it was free during the whole excurfion. In the prefent fcapement both the pallets and detents are detached from the pendulum, except in the moment of unlocking the wheel; fo that the pendulum may be faid to be free during its whole vibration, except during this fhort moment.

ABC (fig. 9.) reprefents a portion of the fwing wheel, of which O is the centre, and A one of the teeth; Z is the centre of the crutch, pallets, and pendulum. The crutch or detents is reprefented of a form refembling the letter A, having in the circular crofs piece a flit *i k*, alfo circular, Z being the centre. This form is very different from Mr Cumming's, and inferior to his, but was adopted here in order to avoid a long defcription. The arm ZF forms the firft detent, and the tooth A is reprefented as locked on it at F. D is the firft pallet on the end of the arm Z *d* moveable round

round the fame centre with the detents, but moveable independently of them. The arm *d e*, to which the pallet D is attached, lies altogether behind the arm ZF of the detent, being fixed to a round piece of brafs *e f g*, which has pivots turning concentric with the verge or axis of the pendulum. To the fame round piece of brafs is fixed the horizontal arm *e* H, carrying at its extremity the ball H, of fuch fize, that the action of the tooth A on the pallet D is juft able (but without any rifk of failing) to raife it up to the pofition here drawn. ZP*p* reprefents the fork, or the pendulum rod, behind both detent and pallet. A pin *p* projects forward, coming through the flit *i k*, without touching the upper or under margin of it. There is alfo attached to the fork the arm *m n* (and a fimilar one on the other fide), of fuch length that, when the pendulum rod is perpendicular, as is reprefented here, the angular diftance of *n q* from the rod *e q* H is precifely equal to the angular diftance of the left fide of the pin *p* from the left end *i* of the flit *i k*.

The mode of action on this apparatus is abundantly fimple. The natural pofition of the pallet D is at *s*, reprefented by the dotted lines, refting on the back of the detent F. It is naturally brought into this pofition by its own weight, and ftill more by the weight of the ball H. The pallet D, being fet on the fore fide of the arm at Z, comes into the fame plane with the detent F and the fwing-wheel. It is drawn, however, in the figure in another pofition. The tooth C of the wheel is fuppofed to have efcaped from the fecond pallet, on which the tooth A immediately engages with the pallet D, fituated at *s*, forces it out, and then refts on the detent F, the pallet D leaning on the tip of the tooth. F is brought into this fituation in a way that will appear prefently. After the efcape of C, the pendulum, moving down the arch of femivibration, is reprefented as having attained the vertical pofition. Proceeding ftill to the left, the pin *p* reaches the extremity *i* of the flit *i k*; and, at the fame inftant, the arm *n* touches the rod *e* H in *q*. The pendulum proceeding a hair's breadth further, withdraws the detent F from the tooth, which now even pufhes off the detent, by acting on the flant face of it. The wheel being now unlocked, the tooth following C on the other fide acts on its pallet, pufhes it off, and refts on its detent, which has been rapidly brought into a proper pofition by the action of A on the flant face of F. It was a fimilar action of C on its detent, in the moment of efcape, which brought F into a fit pofition for locking the wheel by the tooth A. The pendulum ftill going on, the arm *m n* carries the weight of the ball H, and the pallet connected with it, and it comes to reft before the pin *p* again reaches the end of the flit, which had been fuddenly withdrawn from it by the action of A on the flant face of F. The pendulum now returns towards the right, loaded on the left with the ball H, which reftores the motion which it had loft during the laft vibration. When, by its motion to the right, the pin *p* reaches the end *k* of the flit *i k*, it unlocks the wheel on the right fide. At the fame inftant the weight H ceafes to act on the pendulum, being now raifed up from it by the action of a tooth like B on the pallet D.

Let us now confider the mechanifm of thefe motions. The prominent feature of the contrivance is the almoft complete difengagement of the regulator from the wheels. The wheels, indeed, act on the pallets; but the pallets are then detached from the pendulum. The fole ufe of the wheel is to raife the little weights while the pendulum is on the other fide, in order to have them in readinefs at the arrival of the pendulum. They are then laid on the pendulum, and fupply an accelerating force, which reftores to the pendulum the momentum loft during the preceding vibration. Therefore no inequalities in the action of the wheel on the pallets, whether arifing from friction or oil, has any effect on the maintaining power. It remains always the fame, namely, the rotative momentum of the two weights. The only circumftance, in which the irregularity of the action of the wheels can affect the pendulum is at the moment of unlocking. Here indeed the regulator may be affected; but this moment is fo fhort, in comparifon with other fcapements, that it muft be confidered as a real improvement.

It is very uncandid to refufe the author a claim to the character of an ingenious artift on account of this contrivance, as has been done by a very ingenious univerfity Profeffor, who taxes Mr Cumming with ignorance of the *firft elements of mechanics*, and fays that the beft thing in his book is his advice to fufpend the pendulum from a great block of marble, firmly fixed in the wall*. This is certainly a good advice, and we doubt not but that the Profeffor's clock would have performed ftill better if he had condefcended to follow it. It is ftill lefs candid to queftion the originality of the invention. We know for certain that it was invented at a time and place where the author *could* not know what had been done by others. It would have been more like the urbanity of a well-educated man to have acknowledged the genius, which, without fimilar advantages, had done fo much.

* See *Ludlam's Effay*.

But, while we thus pay the tribute of juftice to Mr Cumming, we do not adopt all his opinions. The clock has the fame defects of the former in refpect of the laws of the force which accelerates the pendulum. The fudden addition of the fmall weight, and this almoft at the extremity of the vibration, would derange it very much, if the addition were fufceptible of any fenfible variation. The irregularity of the action of the wheels *may* fenfibly affect the motion during the unlocking, when the clock is foul, and the pendulum *juft* able to unlock; for any difturbance at the extremity of the vibration greatly affects the time. We acknowledge that the parts which we here fuppofe to be foul may not be fo in the courfe of twenty years, thefe parts being only the pivots of the fcapement. The great defect of the fcapement is its liablenefs to unlock by any jolt. It is more fubject to this than the others already mentioned. This rifk is much increafed by the flender make of the parts, in Mr Cumming's drawings, and in the only clock of the kind we have feen; but this is not neceffary: and it fhould be avoided for another reafon; the interpofing fo many flender and crooked parts between the moving power and the pendulum weakens the communication of power, and requires a much more powerful wheelwork.

All thefe, however, are flight defects, and only the laft can be called a fault. The clocks made on this principle have gone remarkably well, as may be feen by the regifters of his majefty's private obfervatory. But the greateft objection is, that they do not perform better

Watch-work.

ter than a well-made dead ſcapement; and they are vaſtly more troubleſome to make and to manage. This is ſtrictly true, and is a ſerious objection. The fact is, that the dominion of a heavy pendulum is ſo great, that if *any one* of the ſcapements now deſcribed be well executed with pallets of agate, and a wheel of hard ſteel, and if the pendulum be ſuſpended agreeably to Mr Cumming's advice, there is hardly any difference to be obſerved in their performance. We ſhall content ourſelves with a ſingle proof of this from fact. The clock invented by the celebrated Harriſon is *at leaſt equal* in its performance to any other. Friction is almoſt annihilated, and no oil is required. It went fourteen years without being touched, and during that time did not vary one complete ſecond from one day to another, nor ever deviated half a minute by accumulation from equable motion: Yet the ſcapement, in ſo far as it reſpects the law of the accelerating force, deviates more from the proportion of the ſpaces than the moſt recoiling ſcapement that ever was put to a good clock. It is ſo different from all hitherto deſcribed, both in form and principle, that we muſt not omit ſome account of it, and with it we ſhall conclude our ſcapements for clocks.

Let GDO repreſent the ſwing-wheel, of which M is the centre. A is the verge or axis of the pendulum. It has two very ſhort arms AB, AE. A ſlender rod BC turns on fine pivots in the joint B, and has at its extremity C a hook or claw, which takes hold of a tooth D of the ſwing-wheel when the pendulum moves from the right ſide to the left. This claw, when at liberty, ſtands at right angles, or, at leaſt, in a certain determinate angle, with regard to the arm AB; and when drawn a little from that poſition, it is brought back to it again by a very ſlender ſpring. The arm AE is furniſhed with a detent EF, which alſo, when at liberty, maintains its poſition on the arm by means of a very ſlender ſpring.

Let us now ſuppoſe that the tooth D is preſſing on the claw C, while the pendulum is moving to the right. The joint B yields, by its motion round A, to the preſſure of the tooth on the claw. By this yielding, the angle ABC opens a little. In the mean time, the ſame motion round A cauſes the point F of the detent on the other ſide to approach the circumference of the wheel in the arch of a circle, and the tooth G at the ſame time advances. They meet, and the point of G is lodged in the notch under the projecting heel *f*. When this takes place, it is evident that any farther motion of the point E round A muſt puſh the tooth G a little backward, by means of the detent EF. It cannot come any nearer to the wheel, becauſe the point of the tooth ſtops the heel *f*. The inſtant that F puſhes G back, the tooth D is withdrawn from the claw C, and C flies out, by the action of its ſpring, and reſumes its poſition at right angles to BA; and the wheel is now free from the claw, but is puſhing at the detent F (c). The pendulum, having finiſhed its excurſion to the right (in which it cauſes the wheel to recoil by means of the detent F), returns toward the left. The wheel now advances again, and, by preſſing on F, aids the pendulum through the whole angle of ſcapement. By this motion the claw C deſcribes an arch of a circle round A, and approaches the wheel, till it take hold of another tooth, namely, the one following D, and pulls it back a little. This immediately frees the detent F from the preſſure of the tooth G, and it flies out a little from the wheel, reſuming its natural poſition by means of its ſpring. Soon after, the motion of the pendulum to the left ceaſes, and the pendulum returns; D pulling forward the hook C to aid the pendulum, and the former operation is repeated, &c. &c.

Such is the operation of the pallets of Harriſon and Hindley. Friction is almoſt totally avoided, and oil entirely (D). The motion is given to the pendulum by a fair pull or puſh, and the teeth of the wheel only apply themſelves to the detents without rubbing. There is no drop, and the ſcapement makes no noiſe, and is what the artiſts call *a ſilent ſcapement*. The mechanician will readily perceive, that by properly diſpoſing the arms AB, AE, and diſpoſing the pallets on the circumference of the wheel, the law, by which the action of the wheel on the pendulum is regulated, may be greatly varied, ſo as to harmonize, as far as the nature of ſcapement, alternately puſhing and pulling, will admit, with the action of gravity.

But this is evidently a recoiling ſcapement, and one of the worſt kind; for the recoil is made at the very confines of the vibration, where every diſturbance of the regular cycloidal vibration occaſions the greateſt diſturbance to the motion. Yet this clock kept time with moſt unexampled preciſion, far excelling all that had been made before, and equal to any that have been made ſince. This is entirely owing to the immenſe ſuperiority of the momentum of the pendulum over the maintaining power.

(c) The reader may here remark the manner in which the preſſure of the tooth G on the detent is transferred to the joint E by the intervention of the ſhank FE, and from the joint E to the pendulum rod, by the intervention of the arm EA. This communication of preſſure is preciſely the ſame that we made uſe of in explaining the common ſcapement. MG, FE, and EA, in this fig. 10. are performing the offices which we then gave to the lines MB, B !, and HA, in fig. 3. Harrriſon's pallet realiſes the abſtract theory.

(D) Mr Harriſon was at firſt by profeſſion a carpenter in a country place. Being extremely ingenious and inventive, he had made a variety of curious wooden clocks. He made one, in particular, for a turret in a gentleman's houſe. Its expoſure made it waſte oil very faſt, and the maker was often obliged to walk two or three miles to renew it, and got nothing for his trouble. In trudging home, not in very good humour, he pondered with himſelf how to make a clock go without oil. He changed all his pinion leaves into rollers; which anſwered very well But the pallets required it more than any other part. After various other projects, he contrived thoſe now repreſented, where there was no friction, and no oil is wanted. The turret clock continued to go without being touched till Mr Harriſon left the country.

II. *Of Scapements for a Watch.*

The execution of a proper ſcapement for watches is a far more delicate and difficult problem than the foregoing, on account of the ſmall ſize, which requires much more accurate workmanſhip, becauſe the error of the hundredth part of an inch has as great a proportion to the dimenſions of the regulator as an inch in a common houſe clock. It is much more difficult on another account. We have no ſuch means of accumulating ſuch a dominion (to uſe Mr Harriſon's expreſſive term) over the wheel-work in the regulator of a watch as in that of a clock. The heavieſt balance that we can employ, without the certainty of ſnapping its pivots by every ſlight jolt, is a mere trifle, in compariſon with the pendulum of the moſt ordinary clock. A dozen or twenty grains is the utmoſt weight of the balance, even of a very large pocket watch. The only way that we can accumulate any notable quantity of regulating power in ſuch a ſmall pittance of matter is by giving it a very great velocity. This we do by accumulating all its weight in the rim, by giving it very wide vibrations, and by making them extremely frequent. The balance-rim of a middling good watch ſhould paſs through at leaſt ten inches in every ſecond. Now, when we reflect on the ſmall momentum of this regulator, the inevitable inequalities of the maintaining power, and the great arch of vibration on which theſe inequalities will operate, and the comparative magnitude even of an almoſt inſenſible friction or clammineſs, it appears almoſt chimerical to expect any thing near to equability in the vibrations, and incredible that a watch can be made which will not vary more than one beat in 86400. Yet ſuch have been made. They muſt be conſidered as the moſt maſterly exertions of human art. The performance of a reflecting teleſcope is a great wonder: the worſt that can find a market muſt have its mirrors executed without an error of the ten-thouſandth part of an inch; but we now know that this accuracy is attained almoſt in ſpite of us, and that we ſcarcely *can* make them of a worſe figure. But the caſe is far otherwiſe in watch work. Here all thoſe wonderful approaches to perfection are the reſults of rational diſcuſſion, by means of ſound principles of ſcience; and, unleſs the artiſt who puts theſe principles into practice be more than a mere copyiſt, unleſs the principles themſelves are perceived by him, and actually direct his hand, the watch may ſtill be good for nothing. Surely, then, this is a liberal art, and far above a manual knack. The ſtudy of the means by which ſuch wonders are ſteadily effected, is therefore the ſtudy of a gentleman.

In the account given above of the ſcapements for pendulums, we aſſumed as one leading principle that *the natural vibrations of a pendulum are performed in equal times, whether wide or narrow.* This is ſo nearly true, when the arches on each ſide of the perpendicular do not exceed four degrees, that the retardation of the wider arches within that limit will not become ſenſible, though accumulated for a long time. The common ſcapement with a plane face of the pallet, helps to correct even this ſmall inequality much better than the niceſt form of the cycloidal cheeks propoſed by Huyghens.

In watch-work we aſſume a ſimilar principle, namely, that *the oſcillations of a balance, urged by its ſpring, and undiſturbed by all foreign forces, are performed in equal times, whether they be wide or narrow.* This principle was aſſumed by the celebrated mechanician Dr Robert Hooke, on the authority of many experiments which he had made on the bending and unbending of ſprings. He found that the force neceſſary for retaining a ſpring in any conſtrained poſition was proportional to its tenſion, or deflection from its natural form. He expreſſed this in an anagram, which he publiſhed about the year 1660, in order to eſtabliſh his claim to the diſcovery, and yet conceal it, till he had made ſome important application of it. When the anagram was explained ſome years afterwards, it was, "*Ut tenſio, ſic vis.*" Dr Hooke thought of applying this diſcovery to the regulation of watch movements. For, if a ſlender ſpring be *properly* applied to the axis of a watch balance, it will put that balance in a certain determinate poſition. If the balance be turned aſide from this poſition, it ſeems to follow that it will be urged back toward it by a force proportional to its diſtance from it. He immediately made the application to an old watch, which he afterward gave to Dr Wilkins, Biſhop of Cheſter. This was in 1658. Its motion was ſo amazingly improved, that Hooke was perſuaded of the perfection of his principle, and thought that nothing was now wanting for making a watch of this kind a perfect chronometer but the hand of a good workman. For his watch ſeemed almoſt perfect, though made in a ſmall country town, in a very coarſe manner. Mr Huyghens alſo claims this diſcovery. He publiſhed his claim about the year 1675, and propoſed to make watches for diſcovering the longitude of a ſhip at ſea. But there is the moſt unqueſtionable evidence of Dr Hooke's priority by fifteen years, and of his having made ſeveral watches of this kind. One of them was in the poſſeſſion of his majeſty king Charles II. Dr Hooke's firſt balance ſpring was ſtraight, and acted on the balance in a very imperfect manner. But he ſoon ſaw the imperfections, and made ſeveral ſucceſſive alterations; and, among others, he employed the cylindrical ſpiral now employed by Mr Arnold; but he gave it up for the flat ſpiral: and the king's watch had one of this kind before Mr Huyghens publiſhed his invention. His project of longitude watches had been carried on along with Lord Brouncker and Sir Robert Moray, and they had quarrelled ſome years before that publication. See Watch, *Encycl.*

But both Dr Hooke and Mr Huyghens were too ſanguine in their expectations. We, by no means, have the evidence for the truth of this principle that we have for the accelerating action of the gravity on a pendulum. It reſts on the nicety and the propriety of the experiments; and long experience has ſhewn that it is ſenſibly true only within certain limits. The demonſtrations by which Bernoulli ſupports the unqualified principle of Mr Huyghens, proceed on hypothetical doctrines concerning the nature of elaſticity. And even theſe ſhew that the law of elaſticity which he aſſumed was ſelected, not becauſe founded on ſimpler principles than any other, but becauſe it was conſiſtent with the experiments of Hooke and Huyghens. Beſides, although this ſhould be the true law of a ſpring, it does not follow that this ſpring, applied in *any way* to the axis of a balance, will urge that balance agreeably to the ſame law: and if it did, it ſtill does not follow that the oſcillations

Watch-work.

tions of the balance will be isochronous; for the force has to move not only the balance but also the spring. Part of the restoring force of the spring is employed in restoring it rapidly to its quiescent shape, and thus enabling it to *follow and still impel* the yielding balance. It is therefore only the surplus which is employed in actually moving the balance, and it is uncertain whether this surplus varies according to the same law, being always the same proportion of the whole force of the spring. We find it an extremely difficult problem to determine the law of variation of this surplus, even in the simplest form of the spring; nay, it is by no means an easy problem to determine the law of oscillation of a spring, unloaded with any balance; and we can easily shew that there are such forms of a spring, that although the velocity with which the different parts approach to their quiescent position be exactly as their excursion from it, this is by no means the law of velocity which this spring will produce in a balance. The matter of fact is, that when the spring is a simple straight steel wire, suspending the balance in the direction of its axis, the motions of it, if not immoderate, are precisely agreeable to Huyghens's and Hooke's rule; and that the motion of a balance urged by a spring wound up into a flat, or a cylindrical spiral, as in common watches, and those of Arnold, deviates sensibly from it, unless a certain analogy be preserved between the length and the elasticity of the spring. If the spring be immoderately long, the wide vibrations are slower than the narrow ones; and the contrary is observed when the spring is immoderately short. A certain taper, or gradual diminution of the spring, is also found to have an effect in equalizing the wide and narrow vibrations. There is also a great difference between the force with which a part of the spring unbends itself, and the action of that force in urging the balance round its axis; and the performance of many watches, good in other respects, is often faulty from the manner in which this unbending force is employed.

But, since these corrections are in our power in a considerable degree, we may suppose them applied, and the true motion (which we shall call the cycloidal) attained; and we may then adapt the construction of the scapement to the preserving this motion undisturbed. And here we must see at once that the problem is incomparably more delicate than in the case of pendulums. The vibrations must be very wide, and the angular motion rapid, that it may be little affected by external motions. The smallest inequalities of maintaining power acting through so great a space, must bear a considerable proportion to the very minute momentum of a watch balance. Oil is as clammy on the pallets of a watch as on those of a clock; a viscidity which would never be felt by a pendulum of 20 pounds weight will stop a balance of 20 grains altogether. For the same reason, it is evident that any impropriety in the form of the pallet must be incomparably more pernicious than in the case of a pendulum; the deviation which this may occasion from a force proportional to the angular distance from the middle point, must bear a great proportion to the whole force.

The common recoiling scapement of the old clocks still holds its place in the ordinary pocket watches, and answers all the common purposes of a watch very well. A well finished watch, with a recoiling scapement, will keep time within a minute in the day. This is enough for the ordinary affairs of life. But such watches are subject to great variation in their rate of going, by any change in the power of the wheels. This is evident; for if the watch be held back, or pressed forward, by the key applied to the fusee square, we hear the beating greatly retarded or accelerated. The maintaining power, in the best of such watches, is never less than one-fifth of the regulating power of the spring. For, if we take off the balance spring, and allow the balance to vibrate by the impulse of the wheels alone, we shall find the minute hand to go forward from 25 to 30 minutes per hour. Suppose it 30. Then, since the wheels act through equal spaces with or without a spring, the forces are as the squares of the acquired velocities. (DYNAMICS, *Suppl.* n° 95.) The velocity in this case is double; therefore the accelerating force is quadruple, and the force of the spring is three times that of the wheels. If the hand goes forward 25 minutes, the force of the wheels is about one-fifth of that of the spring. This great proportion is necessary, as already observed, that the watch may go as soon as unstopped.

We have but little to say on this scapement; its principle and manner of action, and its good and bad qualities, being the same with those of the similar scapement for pendulums. It is evident that the maintaining power being applied in the most direct manner, and during the whole of the vibration, it will have the greatest possible influence to move the balance. A given mainspring and train will keep in motion a heavier balance by means of this scapement than by any other. But, on the other hand, and for the same reason, the balance has less dominion over the wheel-work, and its vibrations are more affected by any irregularities of the wheel-work. Moreover, the chief action of the wheel being at the very extremities of the vibrations, and being very abrupt, the variations in its force are most hurtful to the isochronism of the vibrations.

Although this scapement is extremely simple, it is susceptible of more degrees of goodness or imperfection than almost any other, by the variation of the few particulars of its construction. We shall therefore briefly describe that construction which long experience has sanctioned as approaching near to the best performance that can be obtained from the common scapement. Fig. 11. represents it in what are thought its best proportions, as it appears when looking straight down on the end of the balance arbor. C is the centre of the balance and verge. CA and CB are the two pallets; CA being the upper pallet, or the one next to the balance, and CB being the lower one. F and D are two teeth of the crown wheel, moving from left to right; and E, G, are two teeth on the lower part of the circumference, moving from right to left. The tooth D is represented as just escaped from the point of CA, and the lower tooth E as just come in contact with the lower pallet. The scapement should not, however, be quite so close, because an inequality on the teeth might prevent D from escaping at all. For if E touch the pallet CB before D has quitted CA, all will stand still. This fault will be corrected by withdrawing the wheel a little from the verge, or by shortening the pallets.

The proportions are as follow. The distance between the front of the teeth (that is, of G, F, E, D,) and

 the

the axis C of the balance is one-fifth of FA, the diftance between the points of the teeth. The length CA, CB of the pallets is three-fifths of the fame diftance. The pallets make an angle ACB of 95 degrees, and the front DH or FK of the teeth make an angle of 25° with the axis of the crown wheel. The floping fide of the tooth muft be of an epicycloidal form, fuited to the relative motion of the tooth and pallet.

From thefe proportions it appears that the pallet A can *throw out*, by the action of the tooth D, till it reaches *a*, 120 degrees from CL, the line of the crown-wheel axis. For it can throw out till the pallet B ftrike againft the front of E, which is inclined 25° to CL. To this add BCA, = 95°, and we have LC *a* = 120. In like manner B will throw out as far on the other fide. From 240°, the fum of thefe angles, take the angle of the pallets 95°, and there remains 145° for the greateft vibration which the balance can make without ftriking the front of the teeth. This extent of vibration fuppofes the teeth to terminate in points, and the acting furfaces of the pallets to be planes directed to the very axis of the verge. But the points of the teeth muft be rounded off a little for ftrength, and to diminifh friction on the face of the pallets. This diminifhes the angle of fcapement very confiderably, by fhortening the teeth. Moreover, we muft by no means allow the point of the pallet to bank or ftrike on the forefide of a tooth. This would greatly derange the vibration by the violence and abruptnefs of the check which the wheel would give to the pallet. This circumftance makes it improper to continue the vibrations much beyond the angle of fcapement. One-third of a circle, or 120°, is therefore reckoned a very proper vibration for a fcapement made in thefe proportions. The impulfe of the wheels, or the angle of fcapement, may be increafed by making the face of the pallets a little concave (preferving the fame angle at the centre). The vibration may alfo be widened by pufhing the wheel nearer to the verge. This would alfo diminifh the recoil. Indeed this may be entirely removed by bringing the front of the wheel up to C, and making the face of the pallet not a radius, but parallel to a radius and behind it, *i. e.* by placing the pallet CA fo that its acting face may be where its back is juft now. In this cafe, the tooth D would drop on it at the centre, and lie there at reft, while the balance completes its vibration. But this would make the banking (as the ftroke is called) on the teeth almoft unavoidable. In fhort, after varying every circumftance in every poffible manner, the beft makers have fettled on a fcapement very nearly fuch as we have defcribed. Precife rules can fcarcely be given; becaufe the law by which the force acting on the pallets varies in its intenfity, deviates fo widely from the action of the balance fpring, efpecially near the limits of the excurfions.

The difcoveries of Huyghens and Newton in rational mechanics engaged all the mathematical philofophers of Europe in the folution of mechanical problems, about the end of the laft century. The vibrations of elaftic plates or wires, and their influence on watch balances, became familiar to every body. The great requifites for producing ifochronous vibrations were well underftood, and the artifts were prompted by the fpeculatifts to attempt conftructions of fcapements proper for this purpofe. It appeared clearly, that the moft effectual means for this purpofe was to leave the balance unconnected with the wheels, efpecially near the extremities of the vibration, where the motion is languid, and where every inequality of maintaining power muft act for a longer time, and therefore have a great effect on the whole duration of the vibrations. The maxim of conftruction that naturally arifes from thefe reflections is to *confine*, if poffible, *the action of the wheels to the middle of the vibration*, where the motion is rapid, and where the chief effect of an increafe or diminution of the maintaining power will be to enlarge or contract the angular motions, but will make little change on their duration; becaufe the greateft part of the motion will be effected by the balance fpring alone. This maxim was inculcated in exprefs terms by John Bernoulli, in his *Recherches Mechaniques et Phyfiques*; but it had been fuggefted by common fenfe to feveral unlettered artifts before that time. About the beginning of this century watches were made in London, where the verge had a portion *e d b* (fig. 12.) of a fmall cylinder, having its centre *c* in the axis, and a radial pallet *b a* proceeding from it. Suppofe a tooth juft efcaped from the point of the pallet, moving in the direction *b d e*, the cylindrical part was fo fituated that the next tooth dropped on it at a fmall diftance from its termination. While the verge continues turning in the direction *b d e*, the tooth continues refting on the cylinder, and the balance fuftains no *action* from the wheels, and has only to overcome the minute frictions on the polifhed furface of a hard fteel cylinder. This motion may perhaps continue till the pallet acquires the pofition *f*, almoft touching the tooth. It then ftops, its motion being extinguifhed by the increafing force of the fpring. It now returns, moving in the direction *e d b*; and when the pallet has acquired the pofition *c i*, the tooth *g* quits the circumference of the cylinder, and drops in on the pallet at the very centre. The crooked form of the tooth allows the pallet to proceed ftill farther, before there is any danger of banking on the tooth. This vibration being alfo ended, the balance refumes its firft direction, and the tooth now acts on the face of the pallet, and reftores to the balance all the motion which it had loft by friction, &c. during the two preceding vibrations.

It is evident that this conftruction obviates all the objections to the former recoiling fcapement, and that, by fufficiently diminifhing the diameter of the cylindrical part, the friction may be reduced to a very fmall quantity, and the balance be made to move by the action of the fpring during the whole of the excurfion, and of the returning vibration. Yet this conftruction does not feem to have come much into ufe, owing, in all probability, to the great difficulty of making the drop fo accurate in all the teeth. The fmalleft inequality in the length of a tooth would occafion it to drop fooner or later; and if the cylinder was made very fmall, to diminifh friction, the formation of the notch was almoft a microfcopical operation, and the fmalleft fhake in the axis of the verge or the balance-wheel would make the tooth flip paft the cylinder, and the watch run down amain.

About the fame time, a French artift in London (then the fchool of this art) formed another fcapement, with the fame views. We have not any diftinct account of it, but are only informed (in the 7th volume of the *Machines approuvées par l'Acad. des Sciences*) that the tooth

Watch-work.

tooth refted on the furface of a hollow cylinder, and then efcaped by acting on the inclined edge of it. But we may prefume that it had merit, being there told that Sir Ifaac Newton wore a watch of this kind.

A much fuperior fcapement, on the fame principle, was invented by Mr Geo. Graham, at the fame time that he changed the recoiling fcapement for pendulums into the dead beat. Indeed it is the fame fcapement, accommodated to the large vibrations of a balance. In fig. 13. DE reprefents part of the rim of the balance-wheel. A and C are two of its teeth, having their faces *b e* formed into planes, inclined to the circumference of the wheel, in an angle of about 15 degrees; fo that the length *b e* of the face is nearly quadruple of its height *e m*. Suppofe a circular arch ABC defcribed round the centre of the wheel, and through the middle of the faces of the teeth. The axis of the balance paffes thro' fome point B of this arch, and we may fay that the mean circumference of the teeth paffes through the centre of the verge. On this axis is fixed a portion of a thin hollow cylinder *b c d*, made of hard tempered fteel, or of fome hard and tough ftone, fuch as ruby or fapphire. Agates, though very hard, are brittle. Chalcedony and cornelian are tough, but inferior in hardnefs. This cylinder is fo placed on the verge, that when the balance is in its quiefcent pofition, the two edges *b* and *d* are in the circumference which paffes through the points of the teeth. By this conftruction the portion of the cylinder will occupy 210° of the circumference, or 30° more than a femicircle. The edge *b*, to which the tooth approaches from without, is rounded off on both angles. The other edge *d* is formed into a plane, inclined to the radius about 30°.

Now, fuppofe the wheel preffed forward in the direction AC. The point *b* of the tooth, touching the rounded edge, will pufh it outwards, turning the balance round in the direction *b c d*. The heel *e* of the tooth will efcape from this edge when it is in the pofition *h*, and *e* is in the pofition *f*. The point *b* of the tooth is now at *d*, but the edge of the cylinder has now got to *i*. The tooth, therefore, refts on the infide of the cylinder, while the balance continues its vibration a little way, in confequence of the fhove which it has received from the action of the inclined plane pufhing it out of the way, as the mould board of a plough fhoves a ftone afide. When this vibration is ended, by the oppofition of the balance-fpring, the balance returns, the tooth (now in the pofition B) rubbing all the while on the infide of the cylinder. The balance comes back into its natural pofition *b c d*, with an accelerated motion, by the action of its fpring, and would, of itfelf, vibrate as far, at leaft, on the other fide. But it is aided again by the tooth, which, preffing on the edge *d*, pufhes it afide, till it come into the pofition *k*, when the tooth efcapes from the cylinder altogether. At this moment the other edge of the cylinder is in the pofition *l*, and therefore is in the way of the next tooth, now in the pofition A. The balance continues its vibration, the tooth all the while refting, and rubbing on the outfide of the cylinder. When this vibration, in the direction *d c b*, is finifhed, the balance refumes its firft motion *b c d*, by the action of the fpring, and the tooth begins to act on the firft edge *b*, as foon as the balance gets into its natural pofition, fhoves it afide, efcapes from it, and drops on the infide of the cylinder. In this manner are the vibrations produced, gradually increafed to their maximum, and maintained in that ftate. Every fucceeding tooth of the wheel acts firft on the edge *b*, and then on the edge *d*; refting firft on the outfide, and then on the infide of the cylinder. The balance is under the influence of the wheels while the edge *b* paffes to *h*, and while *d* paffes to *k*; and the reft of the vibration is performed without any *action* on the part of the wheels, but is a little obftructed by friction, and by the clamminefs of the oil. In the conftruction now defcribed, the arch of action or fcapement is evidently 30°, being twice the angle which the face of a tooth makes with the circumference.

The reader will perceive, that when this fcapement is executed in fuch a manner that the fucceeding tooth is in contact with the cylinder at the inftant that the preceding one efcapes from it, the face of the tooth muft be equal to the infide diameter of the cylinder, and that the diftance between the heel of one tooth and the point of the following one muft be equal to the outfide diameter. When the fcapement is fo clofe there is no drop. A good artift approaches as near to this adjuftment as poffible; becaufe, while a tooth is dropping, but not yet in contact, it is not acting on the balance, and fome force is loft. The execution is accounted very good, if the diftance between the centres of two teeth is twice the external diameter of the cylinder. This allows a drop equal to the thicknefs of the cylinder, which is about $\frac{1}{25}$th of its diameter.

We muft alfo explain how this cylinder is fo connected with the verge as to make fuch a great revolution round the tooth of the wheel. The triangular tooth *e b m* is placed on the top of a little pillar or pin fixed into the extremity of the piece of brafs *m* D formed on the rim of the wheel. Thus the wedge-tooth has its plane parallel to the plane of the wheel, but at a fmall diftance above it. Fig. B reprefents the verge, a long hollow cylinder of hard fteel. A great portion of the metal is cut out. If it were fpread out flat, it would have the fhape of fig. C. Suppofe this rolled up till the edges GH and G'H' are joined, and we have the exact form. The part acted on by the point of the tooth is the dotted line *b d*. The part DIFE' ferves to connect the two ends. Thus it appears to be a very flender and delicate piece; but being of tempered fteel, it is ftrong enough to refift moderate jolts. The ruby cylinders are much more delicate.

Such is the cylinder fcapement of Mr Graham, called alfo the HORIZONTAL SCAPEMENT, becaufe the balance wheel is parallel to the others. Let us fee how far it may be expected to anfwer the intended purpofes. If the excurfions of the balance beyond the angle of impulfion were made altogether unconnected with the wheels, the *whole vibration* would be quicker than one of the fame extent, made by the action of the balance-fpring alone, becaufe the middle part of it is accelerated by the wheels. But the excurfions are obftructed by friction and the clamminefs of oil. The effect of this in *obftructing* the motion is very confiderable. Mr Le Roy placed the balance fo, that it refted when the point of the tooth was on the middle of the cylindric furface. When the wheel was allowed to prefs on it, and it was drawn 80° from this pofition, it vibrated only during $4\frac{1}{2}$ feconds. When the wheel was not allowed to touch the cylinder, it vibrated 90 feconds, or 20 times as long;

Watch-work.

long; so much did the friction on the cylinder exceed that of the pivots. We are not sufficiently acquainted with the laws of either of these obstructions to pronounce decidedly whether they will increase or diminish the *time* of the whole vibrations. We observe distinctly, in motions with considerable friction, that it does not increase nearly so fast as the velocity of the motion; nay, it is often less when the velocity is very great. In all cases it is observed to terminate motions abruptly. The friction requires a certain force to overcome it, and if the body has any less it will stop. Now this will not only contract the excursion of the balance, but will shorten the time. But the return to the angle of impulsion will undoubtedly be of longer duration than the excursion; for the arch of return, from the extremity of the excursion to its beginning, where the angle of impulsion ends, is the same with the arch of excursion. The velocity which the balance has in any point of the return is less than what it had in the same point of the excursion; because, in the excursion, it had velocity enough to carry it to the extremity, and also to overcome the friction. In the return, it could, even without friction, only have the velocity which would have carried it to the extremity; and this smaller velocity is diminished by friction during the return. The velocity being less through the whole return than during the excursion, the time must be greater. It may therefore happen that this retardation of the return may compensate the contraction of the excursion and the diminution of its duration. In this case the vibration will occupy the same time as if the balance had been free from the wheels. But it may more than compensate, and the vibrations will then be slower; or it may not fully compensate, and they will be quicker. We cannot therefore say, *à priori*, which of the two will happen: but we may venture to say that an increase of the force of the wheels will make the watch go slower: for this will exert a greater pressure, give a greater impulsion, produce a wider excursion, and increase the friction during that greater excursion, making the wide vibrations slower than the narrow ones; because the angle of impulsion remaining the same, the pressures exerted must be quadrupled, in order to double the excursion (See DYNAMICS, n° 95. *Suppl.*), and therefore the friction will be increased in a greater proportion than the momentum which is to overcome it. But, with respect to the obstruction arising from the viscidity of the oil, we know that it follows a very different law. It bears a manifest relation to the velocity, and is nearly proportional to it. But still it is difficult to say how this will affect the whole vibration. The duration of the excursion will not be so much contracted as by an equal obstruction from friction, because it will not terminate the motion abruptly. There are therefore more chances of the increased duration of the return exceeding the diminution of it in the excursion. All that we can say, therefore, is, that there will be a compensation in both cases. The time of excursion will be contracted, and that of return augmented.

Now, as the friction may be greatly diminished by fine polish, fine oil, and a small diameter of the cylinder, we may reasonably expect that the vibrations of such a balance will not vary nearly so much from isochronism as with a recoiling scapement, and will be little affected by changes in the force of the wheels. Accordingly, Graham's cylindrical scapement supplanted all others as soon as it was generally known. We cannot compare the vibrations with those of a free balance, because we have no way of making a free balance vibrate for some hours. But we find that doubling or trebling the force of the wheels makes very little alteration in the rate of the watch, though it greatly enlarges the angular motion. Any one may perceive the immense superiority of this scapement over the common recoiling scapement, by pressing forward the movement of a horizontal watch with the key, or by keeping it back. No great change can be observed in the frequency of the beats, however hard we press. But a more careful examination shews that an increase of the power of the wheels generally causes the watch to go slower; and that this is more remarkable as the watch has been long going without being cleaned. This shews that the cause is to be ascribed to the friction and oil operating on the wide arches of excursion. But when this scapement is well executed, in the best proportions of the parts, the performance is extremely good. We know such watches, which have continued for several weeks without ever varying more than 7′ in one day from equable motion. We have seen one whose cylinder was not concentric with the balance, but so placed on the verge that the axis of the verge was at *o* (fig. 13.), between the centre B of the cylinder and the entering edge *b*, and B*e* was equal to the thickness of the cylinder. The watch was made by Emery of London, and was said to go with astonishing regularity, so as to equal any time-piece while the temperature of the air did not vary; and when clean, was said to be less affected by the temperature than a watch with a free scapement, but unprovided with a compensation piece. It is evident that this watch must have a minute recoil. This was said to be the aim of the artist, in order to compensate for the obstruction caused by friction during the return of the balance from its excursions. It indeed promises to have this effect; but we should fear that it subjects the excursions to the influence of the wheels. We suspect that the indifferent performance of cylinder watches may often arise from the cylinder being off the centre in some disadvantageous manner.

The watch from which the proportions here stated were taken, is a very fine one made by Graham for Archibald Duke of Argyle, which has kept time with the regularity now mentioned. We believe that there are but few watches which have so large a portion of the cylinder: few indeed have more than one half, or 180° of the circumference. But this is too little. The tooth of the wheel does not begin to act on the resting cylinder till its middle point A or B touch one of the edges. To obtain the same angle of scapement, the inclination of the face of the tooth must be increased (it must be doubled); and this requires the maintaining power to be increased in the same proportion. Besides, in such a scapement it may happen that the tooth will never rest on the cylinder; because the instant that it quits one edge it falls on the other, and pushes it aside, so that the balance acquires no wider vibration than the angle of scapement, and is continually under the influence of the wheels. The scapement is in its best state when the portion of the cylinder exceeds 180° by twice the inclination of the teeth to the circumference of the wheel.

It

It would employ volumes to defcribe all the fcapements which have been contrived by different artifts, aiming at the fame points which Graham had in view. We fhall only take notice of fuch as have fome effential difference in principle.

Fig. 14. reprefents a fcapement invented in France, and called the *Echappement à Virgule*, becaufe the pallet refembles a comma. The teeth A, B, C, of the balance wheel are fet very oblique to the radius, and there is formed on the point of each a pin, ftanding up perpendicular to the plane of the wheel. This greatly refembles the wheel of Graham's fcapement, when the triangular wedge is cut off from the top of the pin on which it ftands. The axis *c* of the verge is placed in the circumference paffing through the pins. The pallet is a plate of hard fteel *a e f d b*, having its plane parallel to the plane of the wheel. The inner edge of this plate is formed into a concave cylindrical furface between *o* and *b*, whofe axis *c* coincides with the axis of the verge. Adjoining to this is the acting face *b d* of the pallet. This is either a ftraight line *b d*, making an angle of nearly 30° with a line *c b g* drawn from the centre, or it is more generally curved, according to the noftrum of the artift. The back of the pallet *a e f* is alfo a cylindrical furface (convex) concentric with the other. This extends about 100° from *a* to *f*. The part between *f* and *d* may have any fhape. The interval *a o* is formed into a convex furface, in fuch a manner as to be everywhere interfected by the radius in an angle of 30° nearly; *i. e.* it is a portion of an equiangular fpiral. The whole of this is connected with the verge by a crank, which paffes perpendicularly through it between *f* and *e*; and the plate is fet at fuch height on the crank or verge, that it can turn round clear of the wheel, but not clear of the pins. The teeth of the wheel are fet fo obliquely, and made fo flender, that the verge may turn almoft quite round without the crank's banking on the teeth. The part *f d b*, called the horn, is of fuch a length, that when one pin B refts on the outfide cylinder at *a*, the point *d* is juft clear of the next pin A.

When the wheel is not acting, and the balance-fpring is in equilibrio, the pofition of the balance is fuch that the point *d* of the horn is near *i*, about 30° from *d*. The figure reprefents it in the pofition which it has when the tooth A has juft efcaped from the point *d* of the horn. In this pofition the next tooth B is applied to the convex cylinder, a very little way (about 5°) from its extremity *a*. This defcription will enable the reader to underftand the operation of the virgule fcapement.

Now fuppofe the pin A juft efcaped from the horn. The fucceeding pin B is now in contact with the back of the cylinder; and the balance, having got an impulfe by the action of A along the concave pallet *b d*, continues its motion in the direction *d g h*, till its force is fpent, the point of the horn arriving perhaps at *h*, more than 90° from *d*. All this while the following tooth B is refting on the back *e f* of the cylinder. The balance now returns, by the action of its fpring; and when the horn is at *i*, the pin gets over the edge *a o*, and drops on the oppofite fide of the concave cylinder, where it refts, while the horn moves from *i* to *k*, where it ftops, the force of the balance being again fpent. The balance then returns; and when the horn comes within 30° of *d*, the pin gets out of the hollow cylinder, fhoves the horn out of its way, and efcapes at *d*. Befides the impulfe which the balance receives by the action of the wheel on the horn *b d*, there is another, though fmaller, action in the contrary direction, while the point of B paffes over the furface *a o*; for this furface being inclined to the radius, the preffure on it urges the balance round in the direction *h d i*.

The chief difference of this fcapement from the former is, that the inclined plane is taken from the teeth of the wheel, and placed on the verge. This alone is a confiderable improvement; for it is difficult to fhape all the teeth alike; whereas the horn *b d* is invariable. Moreover, the refting parts, although they be drawn large in this figure for the fake of diftinctnefs, may be made vaftly fmaller than Graham's cylinder, which muft be big enough to hold a tooth within it. By this change, the friction, during the repofe of the wheel, that is, during the excurfions of the balance, may be vaftly diminifhed. The infide cylinder need be no bigger than to receive the pin. But although the performance of thefe fcapements is excellent, they have not come into general ufe in this country. The caufe feems to be the great nicety requifite in making the pins of the wheel pafs exactly through the axis of the verge. The leaft fhake in the pivots of the balance and balance wheel muft greatly change the action. A very minute increafe of diftance between the pivots will caufe the pin B to flide from the edge *a* to the horn, without refting at all on the infide cylinder; and when it does fo, it will ftop the balance at once, and, immediately after, the watch will run down. The fame irregularities will happen if all the pins be not at precifely the fame diftance from the axis of the wheel.

This fcapement was greatly improved, and, in appearance, totally changed, by Mr Lepaute of Paris in 1753. By placing the pins alternately on the two fides of the rim of the balance-wheel, he avoided the ufe of the outfide cylinder altogether. The fcapement is of fuch a fingular form, that it is not eafy to reprefent it by any drawing. We fhall endeavour, however, to defcribe it in fuch a manner as that our readers, who are not artifts, will underftand its manner of acting. Artifts by profeffion will eafily comprehend how the parts may be united which we reprefent as feparate.

Let ABC (fig. 15.) reprefent part of the rim of the balance-wheel, having the pins 1, 2, 3, 4, 5, &c. projecting from its faces; the pins 1, 3, 5, being on the fide next the eye, but the pins 2 and 4 on the farther fide. D is the centre of the balance and verge, and the fmall circle round D reprefents its thicknefs. But the verge in this place is crooked, like a crank, that the rim of the wheel may not be interrupted by it. This will be more particularly defcribed by and bye. There is attached to it a piece of hard tempered fteel *a b c d*, of which the part *a b c* is a concave arch of a circle, having D for its centre. It wants about 30° of a femicircle. The reft of it *c d* is alfo an arch of a circle, having the fame radius with the balance-wheel. The natural pofition of the balance is fuch, that a line drawn from D, through the middle of the face *c d*, is a tangent to the circumference of the wheel. But, fuppofe the balance turned round till the point *d* of the horn comes to *d'*, and the point *c* comes to 2, in the circumference in which the pins are placed. Then the pin,

pin, preſſing on the beginning of the horn or pallet, puſhes it aſide, ſlides along it, and eſcapes at *d*, after having generated a certain velocity in the balance. So far this ſcapement is like the virgule ſcapement deſcribed already. But now let another pallet, ſimilar to the one now deſcribed, be placed on the other ſide of the wheel, but in a contrary poſition, with the acting face of the pallet turned away from the centre of the wheel. Let it be ſo placed at E, that the moment that the pin 1, on the upper ſide of the wheel, eſcapes from the pallet *c d*, the pin 4, on the under ſide of the wheel, falls on the end of the circular arch *e f g* of the other pallet. Let the two pallets be connected by means of equal pulleys G and F on the axis of each, and a thread round both, ſo that they ſhall turn one way. The balance on the axis D, having gotten an impulſe from the action of the pin 1, will continue its motion from A towards *i*, and will carry the other pallet with a ſimilar motion round the centre E from *h* towards *k*. The pin 4 will therefore reſt on the concave arch *g f e* as the pallet turns round. When the force of the balance is ſpent, the pallet *c d* returns towards its firſt poſition. The pallet *g h* turns along with it; and when the point of the firſt has arrived at *d*, the beginning *g* of the other arrives at the pin 4; and, proceeding a little farther, this pin eſcapes from the concave arch *e f g*, and ſlides along the pallet *g h*, puſhing it aſide, and therefore urging the pallet round the centre E, and conſequently (by means of the connection of the pulleys) urging the balance on the axis D round at the ſame time, and in the ſame direction. The pin 4 eſcapes from the pallet *g h*, when *h* arrives at 3; but in the time that the pin 4 was ſliding along the yielding pallet *g h*, the pin 3 is moving in the circumference BDA; and the inſtant that the pin 4 eſcapes from *h* at 3, the pin 3 arrives at 2, and finds the beginning *c* of the concave arch *c b a* ready to receive it. It therefore reſts on this arch, while the balance continues its motion. This perhaps continues till the point *b* of the arch comes to 2. The balance now ſtops, its force being ſpent, and then returns; and the pin 3 eſcapes from the circle at *c*, ſlides along the yielding pallet *c d*, and when it eſcapes at 1, another pin on the under ſide of the wheel arrives at 4, and finds the arch *g f e* ready to receive it. And in this manner will the vibration of the balance be continued.

This deſcription of the mode of action at the ſame time points out the dimenſions which muſt be given to the parts of the pallet. The length of the pallet *c d* or *g h* muſt be equal to the interval between two ſucceeding pins, and the diſtance of the centres D and E muſt be double of this. The radius D*e* or E *g* may be as ſmall as we pleaſe. The concave arches *c b a* and *g f e* muſt be continued far enough to keep a pin reſting on them during the whole excurſion to the balance. The angle of ſcapement, in which the balance is under the influence of the wheels, is had by drawing D *c* and D *d*. This angle *c* D *d* is about 30°, but may be made greater or leſs.

Fig. B will give ſome notion how the two pallets may be combined on one verge. KL repreſents the verge with a pivot at each end It is bent into a crank MNO, to admit the balance wheel between its branches. BC repreſents this wheel, ſeen edgewiſe, with its pins, alternately on different ſides. The pallets are alſo repreſented edgewiſe by *b c d* and *h g f*, fixed to the inſide of the branches of the crank, fronting each other. The poſition of their acting faces may be ſeen in the preceding figure, on the verge D, where the pallet *g h* is repreſented by the dotted line 2 *i*, as being ſituated behind the pallet *c d*. The remote pallet 2 *i* is placed ſo, that when the point *d* of the near pallet is juſt quitted by a pin 1 on the upper ſide of the wheel, the angle formed by the face and the arch of reſt of the other pallet is juſt ready to receive the next pin 2, which lies on the under ſide of the rim. A little attention will make it plain, that the action will be preciſely the ſame as when the pallets were on ſeparate axes. The pin 1 eſcapes from *d*, and the pin 2 is received on the arch of reſt, and locks the wheel while the balance is continuing its motion. When it returns, 2 gets off the arch of reſt, puſhes aſide the pallet 2 *i*, eſcapes from it when *i* gets to 1, and then the pin 3 finds the point *c* ready to receive it, &c. The vibrations may be increaſed by giving a ſufficient impulſe through the angle of ſcapement. But they cannot be more than a certain quantity, otherwiſe the top N of the crank will ſtrike the rim of the wheel. By placing the pins at the very edge of the wheel, the vibrations may eaſily be increaſed to a ſemicircle. By placing them at the points of long teeth, the crank may get in between them, and the vibrations extended ſtill farther, perhaps to 240°.

This ſcapement is unqueſtionably a very good one; and when equally well executed, ſhould excel Graham's both by having but two acting faces to form (and theſe of hard ſteel or of ſtone), and by allowing us to make the circle of reſt exceedingly ſmall without diminiſhing the acting face of the pallet. This will greatly diminiſh the friction and the influence of oil. But, on the other hand, we apprehend that it is of very difficult execution. The figure of the pallets, in a manner that ſhall be ſuſceptible of adjuſtment and removal for repair, and yet ſufficiently accurate and ſteady, ſeems to us a very delicate job.

Mr Cumming, in his Elements of Clock and Watch-work, deſcribes (ſlightly) pallets of the very ſame conſtruction, making what he conceives to be conſiderable improvements in the form of the acting faces and the curves of reſt. He has alſo made ſome watches with this ſcapement; but they were ſo difficult, that few workmen can be found fit for the taſk; and they are exceedingly delicate, and apt to be put out of order. The connection of the pallets with each other, and with the verge, makes the whole ſuch a contorted figure, that it is eaſily bent and twiſted by any jolt or unſkilful handling.

There remains another ſcapement of this kind, having the tooth of the balance-wheel reſting on a cylindrical ſurface on the axis of the verge during the excurſion, of the balance beyond the angle of ſcapement, and which differs ſomewhat in the application of the maintaining power from all thoſe already deſcribed.

This is known by the name of *Dupleix's ſcapement*, and is as follows: Fig. 16. repreſents the eſſential parts greatly magnified. AD is a portion of the balance-wheel, having teeth *f*, *b*, *g*, at the circumference. Theſe teeth are entirely for producing the *reſt* of the wheel, while the balance is making excurſions beyond the ſcapement. This is effected by means of an agate cylinder *o p q*, on the verge. This cylinder has a notch *o*. When the cylinder turns round in the direction *o p q*, the notch eaſily paſſes the tooth B which is reſting on the cylindric ſurface; but when it returns in the direction *q p o*, the tooth B gets into the notch, and follows it, preſſing on one ſide of it till the notch comes into the poſition *o*. The tooth being then in the poſition *b*, eſcapes from the notch, and another tooth drops on the convex ſurface of the cylinder at B.

The balance-wheel is alſo furniſhed with a ſet of ſtout flat ſided pins, ſtanding upright on its rim, as repreſented by *a*, D. There is alſo fixed on the verge a larger cylinder GFC above the ſmaller one *o p q*, with its under ſurface clear of the wheel, and having a pallet C, of ruby or ſapphire, firmly indented into it, and projecting ſo far as juſt to keep clear of the pins on the wheel. The poſition of this cylinder, with reſpect to the ſmaller one below it, is ſuch that, when the tooth *b* is eſcaped from the notch, the pallet C has juſt paſſed the pin *a*, which was at A while B reſted on the ſmall cylinder; but it moved from A to *a*, while B moved to *b*. The wheel being now at liberty, the pin *a* exerts its preſſure on the pallet C in the moſt direct and advantageous manner, and gives it a ſtrong impulſion, following and accelerating it till another tooth ſtops on the little cylinder. The angle of ſcapement depends partly on the projection of the pallet, and partly on the diameter of the ſmall cylinder and the advance of the tooth B into the notch. Independent of the action on the ſmall cylinder, the angle of ſcapement would be the whole arch of the large cylinder between C and *x*. But *a* ſtops before it is clear of the pallet, and the arch of impulſion is ſhortened by all the ſpace that is deſcribed by the pin while a tooth moves from B to *b*. It ſtops at *a'*.

We are informed by the beſt artiſts, that this ſcapement gives great ſatisfaction, and equals, if it do not excel, Graham's cylindrical ſcapement. It is eaſier made, and requires very little oil on the ſmall cylinder, and none at all on the pallet. They ſay that it is the beſt for pocket watches, and is coming every day more into repute. Theory ſeems to accord with this character. The reſting cylinder may be made very ſmall, and the direct impulſe on the pallet gives it a great ſuperiority over all thoſe already deſcribed, where the action on the pallet is oblique, and therefore much force is loſt by the influence of oil. But we fear that much force is loſt by the tooth B ſhifting its place, and thus ſhortening the arch of impulſion; for we cannot reckon much on the action of B on the ſide of the notch, becauſe the lever is ſo extremely ſhort. Accordingly, all the watches which we have ſeen of this kind have a very ſtrong main ſpring in proportion to the ſize and vibration of the balance. If we leſſen this diminution of the angle of impulſion, by leſſening the cylinder *o p q*, and by not allowing B to penetrate far into the notch, the ſmalleſt inequality of the teeth, or ſhake in the pivots of the balance or wheel, will cauſe irregularity, and even uncertainties in the locking and unlocking the wheel by this cylinder.

A ſcapement exceedingly like this was applied long ago by Dutertre, a French artiſt, to a pendulum. The only difference is, that in the pendulum ſcapement the ſmall cylinder is cut through to the centre, half of it only being left; but the pendulum ſcapement gives a more effective employment of the maintaining power, becauſe the wheel acts on the pallet during the *whole* of the aſſiſted vibration. In a balance ſcapement, if we attempt to diminiſh the inefficient motion of the pin from A to *a*, by leſſening the diameter of the ſmall cylinder, the hold given to the tooth in the notch will be ſo trifling, that the tooth will be thrown out by the ſmalleſt play in the pivot holes, or inequality in the length of the teeth.

With this we conclude our account of ſcapements, where the action of the maintaining power on the balance is ſuſpended during the excurſion beyond the angle of impulſion, by making a tooth reſt on the ſurface of a ſmall concentric cylinder. In ſuch ſcapements, the balance, during its excurſions, is almoſt free from any connection with the wheels, and its iſochroniſm is diſturbed by nothing but the friction on this ſurface.—We come now to ſcapements of more artful conſtruction, in which the balance is really and completely free during the whole of its excurſion, being altogether diſengaged from the wheelwork. Theſe are called DETACHED SCAPEMENTS. They are of more recent date. We believe that Mr Le Roi was the firſt inventor of them, about the year 1748. In the Memoirs of the Academy of Paris for that year, and in the Collection of approved Machines and Inventions, we have deſcriptions of the contrivance. The balance wheel reſts on a detent, while the balance is vibrating in perfect freedom. It has a pallet ſtanding out from the centre, which, in the courſe of vibration, paſſes cloſe by the point of a tooth of the wheel. At that inſtant a pin, connected with this pallet, withdraws the detent from the wheel, and the tooth juſt now mentioned follows the pallet with rapidity, and gives it a ſmart puſh forward. Immediately after, another tooth of the wheel meets the other claw of the detent, and the wheel is again locked. When the balance returns, the pin puſhes the detent back into its former place, where it again locks the wheel. Then the balance, reſuming its firſt direction, unlocks the wheel, and receives another impulſion from it. Thus the balance is unconnected with the wheels, except while it gets the impulſion, and at the moments of unlocking the wheels.

This contrivance has been reduced to the greateſt poſſible ſimplicity by the Britiſh artiſts, and ſeems ſcarcely capable of farther improvement. The following is one of the moſt approved conſtructions. In fig. 17. *a b c* repreſents the pallet, which is a cylinder of hard ſteel or ſtone, having a notch *a b*. A portion of the balance wheel is repreſented by A B. It is placed ſo near to the cylinder that the cylinder is no more than clear of *two adjoining* teeth. DE is a long ſpring, ſo fixed to the watch-plate at E, as to preſs very gently on the ſtop pin G. A ſmall ſtud F is fixed to that ſide of the ſpring that is next to the wheel. The tooth of the wheel reſts on this ſtud, in ſuch a manner that the tooth *a* is juſt about to touch the cylinder, and the tooth *f* is juſt clear of it. Another ſpring, extremely ſlender, is attached to the ſpring DE, on the ſide next the balance wheel, and claps cloſe to it, but keeping clear of the ſtud F, and having its point *o* projecting about $\frac{1}{10}$th of an inch beyond its extremity. When the point *o* is preſſed towards the wheel, it yields moſt readily; but, when preſſed in the oppoſite direction, it carries the ſpring DE along with it. The cylinder being ſo placed on the verge that the edge *a* of the notch is

Watch-work.

is close by the tooth a, a hole is drilled at i, close by the projecting point of the slender spring, and a small pin is driven into this hole. This is the whole apparatus; and this situation of the parts corresponds to the quiescent position of the balance.

Now, let the balance be turned out of this position 80 or 90 degrees, in the direction $a\,b\,c$. When it is let go, it returns to this position with an accelerated motion. The pin i strikes on the projecting point of the slender spring, and, pressing the strong spring DE outward from the wheel, withdraws the stud F from the tooth; and thus unlocks the wheel. The tooth a engages in the notch, and urges round the balance. The pin i quits the slender spring before the tooth quits the notch; so that when it is clear of the pallet, the wheel is locked again on the stud F, and another tooth g is now in the place of a, ready to act in the same manner. When the force of the balance is spent, it stops, and then returns toward its quiescent position with a motion continually accelerated. The pin i arrives at the point o of the slender spring, raises it from the strong spring without disturbing the latter, and almost without *being* disturbed by this trifling obstacle; and it goes on, turning in the direction $a\,b\,c$, till its force is again spent; it stops, returns, again unlocks the wheel, and gets a new impulsion. And in this manner the vibrations are continued. Thus we see a vibration, almost free, maintained in a manner even more simple than the common crutch scapement. The impulse is given direct, without any decomposition by oblique action, and it is continued through the *whole* motion of the wheel. No part of this motion is lost, as in Dupleix's scapement, by the *gradual* approach of the tooth to its active position. Very little force is required for unlocking the wheel, because the spring DFE is made slender at the remote end E, so that it turns round E almost like a lever turning on pivots. A sudden twitch of the watch, in the direction $b\,a$, might chance to unlock the wheel. But this will only derange one vibration, and even that not considerably, because the teeth are so close to the cylinder that the wheel cannot advance till the notch comes round to the place of scapement. A tooth will continue pressing on the cylinder, and by its friction will change a little the extent and duration of a single vibration. The greatest derangement will happen if the wheel should thus unlock by a jolt, while the notch passes through the arch of scapement in the returning vibration. Even this will not greatly derange it, when the watch is clean and vibrating wide; because, in this position, the balance has its greatest momentum, and the direction of the only jolt that can unlock the wheel tends to increase this momentum relatively. In short, considering it theoretically, it seems an almost perfect scapement; and the performance of many of these watches abundantly confirms that opinion. They are known to keep time for many days together, without varying one second from day to day; and this even under considerable variations of the maintaining power. Other detached scapements may equal this, but we scarcely expect any to exceed it; and its simplicity is so much superior to any that we have seen, that, on this account, we are disposed to give it the preference. We do not mean to say that it is the best for a pocket watch. Perhaps the scapement of Dupleix or Graham may be preferable, as being susceptible of greater strength, and more able to withstand jolts. Yet it is a fact that some of the watches made in this form by Arnold and others have kept time in the wonderful manner abovementioned while carried about in the pocket.

Mr Mudge of London invented, about the year 1763, another detached scapement, of a still more ingenious construction. It is a counterpart of Mr Cumming's scapement for pendulums. The contrivance is to this effect. In fig. 18. $a\,b\,c$ represents the balance. Its axis is bent into a large crank EFGHIK, sufficiently roomy to admit within it two other axes M and L, with the proper cocks for receiving their pivots. The three axes form one straight line. About these smaller axes are coiled two auxiliary springs, in opposite directions, having their outer extremities fixed in the studs A and B. The balance has its spring also, as usual, and the three springs are so disposed that each of them alone would keep the balance at rest in the same position, which we may suppose to be that represented in the figure. The auxiliary springs A and B are connected with the balance only occasionally, by means of the arms m and n projecting from their respective axes. These arms are catched on opposite sides by the pins o, p, in the branches of the crank; so that when the balance turns round, it carries one or other of those arms round with it, and, during this motion, it is affected by the auxiliary spring connected with the arm so carried round by it.

Let us suppose that the balance vibrates 120° on each side of its quiescent position $a\,b\,c$, so that the radius Ea acquires, alternately, the positions Eb and Ec. The auxiliary springs are connected with the wheels by a common dead-beat pendulum scapement, so that each can be separately wound up about 30°, and retained in that position. Let us also suppose that the spring A has been wound up 30° in the direction $a\,b$, by the wheel-work, and that the point a of the rim of the balance, having come from c, is passing through a with its greatest velocity. When the radius Ea has passed a 30° in its course toward b, the pin o finds the arm m in its way, and carries it along with it till a gets to b. But, by carrying away the arm m, it has unlocked the wheel-work, and the spring B is now wound up 30° in the other direction, but has no connection with the balance during this operation. Thus the balance finishes its semivibration $a\,b$ of 120°, opposed by its own spring the whole way, and by the auxiliary spring A through an angle of 90°. It returns to the position Ea, aided by A and by the balance-spring, through an angle of 120°. In like manner, when Ea has moved 30° toward the position Ec, the pin p meets with the arm n, and carries it along with it through an angle of 90°, opposed by the spring B, and then returns to the position Ea, assisted by the same spring through an arch of 120°.

Thus it appears that the balance is opposed by each auxiliary spring through an angle of 90°, and assisted through an angle of 120°. This difference of action maintains the vibrations, and the necessary winding up of the auxiliary springs is performed by the wheel-work, at a time when they are totally disengaged from the balance. No irregularity of the wheel-work can have any influence on the force of the auxiliary springs, and therefore the balance is completely disengaged from all

all these irregularities, except in the short moment of unlocking the wheel that winds up the springs.

This is a most ingenious construction, and the nearest approach to a free vibration that has yet been thought of. It deserves particular remark that, during the whole of the returning or accelerated semivibration, the united force of the springs is proportional to the distance from the quiescent position. The same may be said of the retarded excursion beyond the angle of impulse: therefore the only deviation of the forces from the law of cycloidal vibration is during the motion from the quiescent position to the meeting with the auxiliary spring. Therefore, as the forces, on both sides, beyond this angle, are in their due proportion, and the balance always makes such excursions, there seems nothing to disturb the isochronism, whether the vibrations are wide or narrow. Accordingly, the performance of this scapement, under the severest trials, equalled any that were compared with it, in as far as it depended on scapement alone. But it is evident that the execution of this scapement, though most simple in principle, must always be vastly more difficult than the one described before. There is so little room, that the parts must be exceedingly small, requiring the most accurate workmanship. We think that it may be greatly simplified, preserving all its advantages, and that the parts may be made of more than twice their present size, with even less load on the balance from the inertia of matter. This improvement is now carrying into effect by a friend.

Still, however, we do not see that this scapement is, theoretically, superior to the last. The irregularities of maintaining power affect that scapement only in the arch of impulsion, where the velocity is great, and the time of action very small. Moreover, the chief effect of the irregularities is only to enlarge the excursions; and in these the wheels have no concern.

Mr Mudge has also given another detached scapement, which he recommends for pocket watches, and executed entirely to his satisfaction in one made for the Queen. A dead beat pendulum scapement is interposed, as in the last, between the wheels and the balance. The crutch EDF (fig. 19.) has a third arm DG, standing outwards from the meeting of the other two, and of twice their length. This arm terminates in a fork AGB. The verge V has a pallet C, which, when all is at rest, would stand between the points A, B of the fork. But the wheel, by its action on the pallet E, forces the fork into the position B g b, the point A of the fork being now where B was before, just touching the cylindrical surface of the verge. The scapement of the crutch EDF is not accurately a dead beat scapement, but has a very small recoil beyond the angle of impulsion. By this circumstance the branch A (now at B) is made to press most gently on the cylinder, and keeps the wheel locked, while the balance is going round in the direction BHA. The point A gets moving from A to B by means of a notch in the cylinder, which turns round at the same time by the action of the branch AG on the pallet C; but A does not touch the cylinder during this motion, the notch leaving free room for its passage. When the balance returns from its excursion, the pallet C strikes on the branch A (still at B), and unlocks the wheel. This now acting on the crutch pallet F, causes the branch b of the fork to follow the pallet C, and give it a strong impulse in the direction in which it is then moving, causing the balance to make a semivibration in the direction AHB. The fork is now in the situation A g a, similar to B g b, and the wheel is again locked on the crutch pallet E.

The intelligent reader will admit this to be a very steady and effective scapement. The lockage of the wheel is procured in a very ingenious manner; and the friction on the cylinder, necessary for effecting this, may be made as small as we please, notwithstanding a very strong action of the wheel: For the pressure of the fork on the cylinder depends entirely on the degree of recoil that is formed on the pallets E and F. *Pressure* on the cylinder is not *indispensably* necessary, and the crutch scapement might be a real dead beat. But a small recoil, by keeping the fork in contact with the cylinder, gives the most perfect steadiness to the motion. The ingenious inventor, a man of approved integrity and judgment, declares that her Majesty's watch was the best pocket watch he had ever seen. We are not disposed to question its excellency. We saw an experiment watch of this construction, made by a country artist, having a balance so heavy as to vibrate only twice in a second. Every vibration was sensibly beyond a turn and a half, or 540°. The artist assured us, that when its proper balance was in, vibrating somewhat more than five times in a second, the vibrations even exceeded this. He had procured it this great mobility by substituting a roller with fine pivots in place of the simple pallet of Mudge. This great extent of detached vibration is an unquestionable excellence, and is peculiar to those two scapements of this ingenious artist.

Very ingenious scapements have been made by Ernshaw, Howel, Hayley, and other British artists; and many by the artists of Paris and Geneva. But we must conclude the article, having described all that have any difference in principle.

The scapement having been brought to this degree of perfection, we have an opportunity of making experiments on the law of action of springs, which has been too readily assumed. We think it easy to demonstrate, that the figure of a spring, which must have a great extent of rapid motion, will have a considerable influence on the force which it impresses on a balance *in actual motion*. The accurate determination of this influence is not very difficult in some simple cases. It is the greatest of all in the plane spiral, and the least in the cylindrical; and, in this last form, it is so much less as the diameter is less, the length of the spring being the same. By employing many turns, in order to have the same ultimate force at the extremity of the excursion, this influence is increased. A particular length of spring, therefore, will make it equal to a given quantity; and it may thus compensate for a particular magnitude of friction, and other obstructions. This accounts for the observation of Le Roy, who found that every spring, *when applied to a movement*, had a certain length, which made the wide and narrow vibrations isochronous. His method of trial was so judicious, that there can be no doubt of the justness of his conclusion. His time keeper had no fuzee; and when the last revolution of the main wheel was going on, the vibrations were but of half the extent of those made during the first revolution. Without minding the real rate of going, he only compared the

Water.

the duration of the firſt and laſt revolution of the minute hand. An artiſt of our acquaintance repeated theſe experiments, and with the ſame reſult: But, unfortunately, could derive little benefit from them; becauſe in one ſtate of the oil, or with one balance, he found the lengths of the ſame ſpring, which produced iſochronous vibrations, were different from thoſe which had this effect in another ſtate of the oil, or with another balance. He alſo obſerved another difference in the rate, ariſing from a difference of poſition, according as XII, VI, III, or IX, was uppermoſt; which difference plainly ariſes from the ſwagging of the ſpring by its weight, and, in that ſtate, acting as a pendulum. This unluckily put a ſtop to his attempts to leſſen this hurtful influence by employing a cylindrical ſpiral of ſmall diameter and great length.

WATER-Blowing Machine, called in French *Soufflet d'eau* or *trompe*, is a machine which, by the action of falling water, ſupplies air to a blaſt furnace. It conſiſts of an upright pipe, through which a ſhower of water is made to fall; and this ſhower carries down with it a maſs of air, which is received beneath in a kind of tub, and conducted to the furnace by means of a pipe. The firſt idea of ſuch a machine was doubtleſs ſuggeſted by thoſe local winds, which are always produced by natural falls of water over precipices, and in the mountains (ſee page 277 of this Volume); but perhaps we are indebted for the firſt accurate theory of it to Profeſſor Venturi.

That philoſopher, in his experimental reſearches concerning the lateral communication of motion in fluids, proves that the water-blowing machine affords air to the furnace, by the accelerating force of gravity and the lateral communication of motion combined together. He begins with an idea, which, he candidly acknowledges, did not eſcape the penetration of Leonardo Da Vinci. Suppoſe a number of equal balls to move in contact with each other along the horizontal line AB (Plate XLVI. fig. 1.). Imagine them to paſs with an uniform motion, at the rate of four balls in a ſecond. Let us take BF, equal to 16 feet Engliſh. During each ſecond four balls will fall from B to F, and their reſpective diſtances in falling will be nearly BC = 1, CD = 3, DE = 5, EF = 7. We have here a very evident repreſentation of the ſeparation, and ſucceſſive elongation, which the accelerating force of gravity produces between bodies which fall after each other.

The rain water flows out of gutters by a continued current; but during its fall it ſeparates into portions in the vertical direction, and ſtrikes the pavement with diſtinct blows. The water likewiſe divides, and is ſcattered in the horizontal direction. The ſtream which iſſues out of the gutter may be one inch in diameter, and ſtrike the pavement over the ſpace of one foot. The air which exiſts between the vertical and horizontal ſeparations of the water which falls, is impelled and carried downwards. Other air ſucceeds laterally; and in this manner a current of air or wind is produced round the place ſtruck by the water. Hence the following idea of a water-blowing maching:

Let BCDE (fig. 2.) repreſent a pipe, through which the water of a canal AB falls into the lower receiver, MN. The ſides of the tube have openings all round, through which the air freely enters to ſupply what the water carries down in its fall. This mixture of water and air proceeds to ſtrike a maſs of ſtone Q; whence rebounding through the whole width of the receiver MN, the water ſeparates from the air, and falls to the bottom at XZ, whence it is diſcharged into the lower channel or drain, by one or more openings TV. The air being leſs heavy than the water, occupies the upper part of the receiver; whence being urged through the upper pipe O, it is conveyed to the forge.

It has been ſuppoſed by ſome eminent chemiſts, that the air which paſſes through the pipe O is furniſhed by the decompoſition of water. To aſcertain whether this be the caſe or not, our author formed a water-blowing engine of a ſmall ſize. The pipe BD was two inches in diameter, and four feet in height. When the water accurately filled the ſection BC, and all the lateral openings of the pipe BDEC were cloſed, the pipe O no longer offered any wind. It is therefore evident, that in the open pipes the whole of the wind comes from the atmoſphere, and no portion is afforded by the decompoſition of water. It remains, therefore, to determine the circumſtances proper to drive into the receiver MN the greateſt quantity of air, and to meaſure that quantity.

1. To obtain the greateſt effect from the acceleration of gravity, it is neceſſary that the water ſhould begin to fall at BC, (fig. 2.) with the leaſt poſſible velocity; and that the height of the water FB ſhould be no more than is neceſſary to fill the ſection BC. Our author ſuppoſes the vertical velocity of this ſection to be produced by an height or head equal to BC.

2. We do not yet know, by direct experiment, the diſtance to which the lateral communication of motion between water and air can extend itſelf; but we may admit with confidence, that it can take place in a ſection double that of the original ſection with which the water enters the pipe. Let us ſuppoſe the ſection of the pipe BDEC to be double the ſection of the water at BC; and, in order that the ſtream of fluid may extend and divide itſelf through the whole double ſection of the pipe, ſome bars, or a grate, are placed in BC, to diſtribute and ſcatter the water through the whole internal part of the pipe.

3. Since the air is required to move in the pipe O with a certain velocity, it muſt be compreſſed in the receiver. This compreſſion will be proportioned to the ſum of the accelerations, which ſhall have been deſtroyed in the inferior part KD of the pipe. Taking KD = 1,5 feet, we ſhall have a preſſure ſufficient to give the requiſite velocity in the pipe O. The ſides of the portion KD, as well as thoſe of the receiver MN, muſt be exactly cloſed in every part.

4. The lateral openings in the remaining part of the pipe BK may be ſo diſpoſed and multiplied, particularly at the upper part, that the air may have free acceſs within the tube. We will ſuppoſe them to be ſuch that 0,1 foot height of water might be ſufficient to give the neceſſary velocity to the air at its introduction through the apertures.

All theſe conditions being attended to, and ſuppoſing the pipe BD to be cylindrical, it is required to determine the quantity of air which paſſes in a given time through the circular ſection KL. Let us take in feet KB = 1,5; BC = BF = a; BD = b. By the common theory of falling bodies, the velocity in KL will be $7{,}76 \sqrt{(a+b-1{,}4)}$; the circular ſection KL = 0,785

Water, Weaving. Weaving

$0{,}785\,a^2$. Admitting the air in KL to have acquired the fame velocity as the water, the quantity of the mixture of the water and air which paffes in a fecond through KL is $= 6,\ 1\,a^2 \sqrt{(a + b - 1{,}4)}$. We muft deduct from the quantity $(a + b - 1{,}4)$ that height which anfwers to the velocity the water muft lofe by that portion of velocity which it communicates to the air laterally introduced; but this quantity is fo fmall that it may be neglected in the calculation. The water which paffes in the fame time of one fecond thro' BC is $= 0{,}4\,a^2 \sqrt{(a + 0{,}1)}$. Confequently, the quantity of air which paffes in one fecond through KL, will be $= 6,\ 1\,a^2 \sqrt{(a + b - 1{,}4)} - 0{,}4\,a^2 \sqrt{(a + 0{,}1)}$, taking the air itfelf, even in its ordinary ftate of compreffion, under the weight of the atmofphere. It will be proper, in practical applications, to deduct one-fourth from this quantity; 1. On account of the fhocks which the fcattered water fuftains againft the inferior part of the tube, which deprive it of part of its motion; and, 2. Becaufe it muft happen that the air in LK will not, in all its parts, have acquired the fame velocity as the water.

If the pipe O do not difcharge the whole quantity of air afforded by the fall, the water will defcend at XZ; the point K will rife in the pipe, the afflux of air will diminifh, and part of the wind will iffue out of the lower lateral apertures of the pipe BK.

We fhall not here examine the greater or lefs degree of perfection of the different forms of water-blowing machines which are ufed at various iron forges; fuch as thofe of the Catalans, and elfewhere. Thefe points may be eafily determined from the principles here laid down, compared with thofe eftablifhed in the articles *Resistance of Fluids (Encycl.)*, and Dynamics (*Supplement*.).

WEAVING (fee *Encycl.*) is an operation which, by means of a well-known inftrument called the *weaving-loom*, has hitherto been performed by bodily labour. That labour is pretty fevere; and Mr Robert Millar, an ingenious calico printer in the county of Dumbarton, Scotland, wifhing to leffen it, invented, fome years ago, a weaving-loom, which may be wrought by water, fteam, horfes, or any other power. For his invention he received a patent, dated June 26th 1796; and though truth compels us to fay, that we do not think it likely to emulate the fpinning machine of Arkwright, it is fufficiently ingenious to deferve notice in a Work of this kind. The following is his own defcription of his patent weaving-loom:

Fig. 1. (Plate L.) reprefents a fide view of the loom, AA, BB, CC, DD, being the frame. *a* is an axis (which we fhall call the fpindle) acrofs the frame. On this axis is a fheeve *b*, two inches thick, having a groove round it, two inches deep, and half an inch wide. The bottom of this groove is circular, except in one part *c*, where it is filled up to the top; a lever *d* refts on the bottom of this groove, and is lifted up by it when the elevation *c* comes round to the fituation reprefented in the figure. By this motion, the lever *d* acts on the ratchet-wheel *e* by the catch *t*, and draws it forward one tooth, each revolution of the fheeve. This ratchet wheel is in an iron frame *gg*, which alfo properly carries the two catches *t* and *u*, which are connected with it at *v*. The catch *u* holds the ratchet-wheel in its pofition, while the lever *d*, and the catch *t*, are moved by the groove *c* in the fheeve. On the arbor of the ratchet is a fmall pinion *h*, working in the wheel *f*; this wheel is fixed on the end of the roller *e* of fig. 3. On the fide of the fheeve *b* is fixed a wiper *k*, which lifts the treadle *l*. This treadle turns on its joints in the fheeve E, which is fixed to the fide of the frame A and D; it is kept preffing on the bottom of the groove in the fheeve by a fpring *m*, fixed to the frame fide A, and having a flender rod *n* from its extremity, joining it with the treadle at *l*. From the point of the treadle there goes a belt *o*, which paffes over the pulley *p*, which is feen edgewife in this figure, and is joined to the top of the fly pin *q*, of fig. 2. At the end of the frame A is the fhort poft F; on this refts the yarn-beam *j*, having a fheeve *r*, over which paffes a cord, having a weight *s* fufpended to it. The other end of this cord is faftened to the fpring *v*; the weight caufes the yarn-beam to ftretch the web from the ratchet wheel *e*, with its catch *u*; and the fpring *v* allows the rope to flide on the fheeve as the ratchet is drawn round during the working.

Fig. 2. is a front view of the loom. *a a* is the fpindle which carries the fheeve *b*, and the wipers *d* and *d*, which move the treadles *w*, *w*, of fig. 1. Thefe ufe the treadles of the headles, with which they are connected by cords from the fhafts of the headles *s*, *s*. From the upper fhaft there go two leathern belts *f*, *f*, to the roller *y*, furnifhed each with a buckle, for tightening them at pleafure. The two wipers *c*, *c*, on the fhaft *a*, which ferve for taking back the lay, have the two treadles *x*, *x*, in fig. 3. with a belt from each paffing over the roller *b* 2 of fig. 1. and fixed to the fword of the lay. From the fwords of the lay forward is fixed a belt to each end of the roller *i*; from this roller there goes a cord to the fpring *j*, which ferves for taking forward the lay which is hinged on the rocking tree *t*. The ftar-wheel *b* of fig. 3. and the fheeve *b* of fig. 1. are fixed to the oppofite ends of the fpindle *a* without the frame; and both the wheel and fheeve have a wiper *k* fixed to them for moving the treadles. In order to drive the fhuttle, the belts *o*, *o*, go from the points of the treadles, over the pulleys *p*, *p*. to the top of the fly-pin *q*: This turns on a pin-joint in a rail *r*, which goes acrofs the loom. From its lower end there go two fmall cords to the fhuttle drivers *g*, *g*, which flide on the iron rods *n*, *n*. A long iron rod *v* goes acrofs the lay, and is hung on two centres at the ends. In this rod *v* are fixed two fmall crooked wires *w*, *w*, which are more diftinctly marked in the little figure *w* above, which reprefents a fection of the lay. The dot at the lower end of the wire *w*, in this figure, is the fection of the rod *v*. The fhuttle paffes between thefe wires and the lay every fhot, and lifts them up, caufing the rod *v* to turn round a little. But if the fhuttle fhould not pafs thefe wires, nor lift them, it would be drawn home by the lay, and deftroy the web. To prevent this, there is fixed on one end of the rod *v* a ftout crooked wire *z*, having a broad or flat head, which naturally refts on a plate of iron, marked and fixed to the back of the lay. This plate has a flit in its middle about an inch deep. In this flit refts the rod *a* 2 of fig. 3. on which is a fhort ftud. which is caught by the wire *z* when the wire *w* is not lifted back by the paffing fhuttle. This will ftop the lay from coming home, and will fet off the loom.

Fig. 3. is another fide-view of the loom oppofite

fite to fig. 1. On the fpindle *a* is the ftar wheel *b*, on the outfide of the loom frame, on the arms of which wheel is fixed the wiper *k*, as the fimilar wiper is fixed to the fheeves on the other end of the fpindle. The wipers which drive the fhuttles are fixed on oppofite fquares of the fpindle, and work alternately. Below the ftar-wheel is a pinion *e*, which is on a round fpindle, turned by the water-wheel, by means of a wheel on this fpindle. In a wheel on this fpindle are two ftuds, on which the pinion *c* flides off and on as the loom is fet off and on by the lever *d*. At the farther end of this lever is the weight *s*, hanging by a cord which paffes over a pulley *t*, fixed at the outer end of the fpring-catch on which the lever *d* refts; and thus the loom is drawn in at the upper end of the lever *d*. But when the fhuttle does not lift the wire *z*, it catches on the ftud on the rod *a* 2, which is conneĉted with the fpring-catch, and the lever *d* flies off with the weight *s*, and the loom ftops working. On the head of the poft F is the yarn-beam. The rollers *e* and *f* are cylinders, preffed together by a fcrew lever, and take away the cloth between them at a proper rate. In the roller *f* is a groove for a band for driving the roller *g*, on which the cloth winds itfelf as it is wrought. Wherever fprings are mentioned to be ufed in the above defcription, weights may be ufed in their ftead, and to the fame effeĉt, and more efpecially upon the treadle of fig. 1. for driving the fhuttle.

WEIGHTS AND MEASURES, in commerce, are fo various, not only in different countries, but even in different provinces of the fame country, and this variation is the fource of fo much inconveniency in trade, that writers on polical and commercial economy have propofed various methods for fixing an univerfal and immoveable ftandard of weights and meafures for all ages and nations. Sir James Stewart Denham's fpeculations on this fubjeĉt have been noticed in his life publifhed in this *Supplement*; Mr Whithurft's ingenious contrivance for eftablifhing a ftandard of weights and meafures has been mentioned under the title MEASURE (*Encycl.*); and the new table of weights and meafures, which the French republicans wifh to impofe upon all Europe, is given (*Encycl.*) under the title REVOLUTION, n° 183.

As thefe meafures occur frequently, even in Englifh tranflations of French books of value, we fhall here give fuch an account of them as may enable the reader to reduce them with eafe to the Englifh ftandards. They are of five kinds; *meafures of length, of capacity, of weight, of fuperficies for land, and of wood for fuel.* For every kind, there are many meafures of different fizes, one of which has been taken as the bafis of all the reft, and its name affumed as the root of their names. Thus METRE is called the principal meafure of length; LITRE, of capacity; GRAMME, of weight; ARE, of fuperficies of land; and STERE, of wood for fuel. Thefe words being the radical terms of the names of other meafures of length, capacity, &c. a relation is hereby preferved between the names.

The meafures of length above the *metre*, are ten times, a hundred times, a thoufand times, ten thoufand times, greater than the metre. The meafures of length below the metre, are ten times, a hundred times, a thoufand times, lefs. To form the names of thefe meafures, other words which indicate the relations of *ten times*, a *hundred times*, greater; and of *ten times*, a *hundred times*, lefs, &c. are placed before the word *metre*. The fame annexes have been ufed to form the names of meafures, greater or lefs, than the *litre*, the *gramme*, &c. It is neceffary, therefore, to ftate in this place the Englifh equivalents of only the *metre*, the *litre*, the *gramme*, the *are*, and the *ftere*.

The METRE = 3.28084 feet Englifh.

The LITRE = 61.0243 cubic inches, or $1\frac{101}{141}$ pint ale meafure.

The GRAMME, or cubic *centi metre* of water, at the freezing point, = $\frac{1}{454}$ lb. averd. or $\frac{1}{28}$ of an ounce, or $\frac{26}{45}$ of a dram nearly.

The ARE = $1076\frac{2}{5}$ fquare feet, or $119\frac{3}{5}$ fquare yards, or $\frac{1}{40}$ of an acre nearly.

The STERE, or cubic metre = 35.31467 cubic feet.

The better part of our countrymen, not choofing to adopt the weights and meafures prefcribed to them by the French Convention and the National Inftitute, Sir George Shuckburgh Evelyn, Bart. turned his attention to this fubjeĉt, and publifhed, in the Philofophical Tranfaĉtions for 1798, an account of fome endeavours to afcertain a ftandard of weights and meafures. The principles upon which he proceeded are the fame with Mr Whitehurft's; but he has carried his experiments much farther than his predeceffor, and feems to have conduĉted them with greater accuracy. His memoir is hardly fufceptible of abridgment; and our limits do not permit us to infert it entire. This is indeed unneceffary, if it be true, as another ingenious gentleman alleges *, that we are in the aĉtual poffeffion, and the conftant ufe, of a ftandard both for weight and meafure, as invariable as that now ufed in France. This ftandard he finds in the foot meafure, and in the avoirdupoife, or, as he thinks it ought to be called, the *decade* ounce weight.

* H. Goodwin, Efq. in *Nicholfon's Journal*, vol. iv. p. 163, &c.

The decade ounce weight of pure rain, or diftilled water, at 60° of heat, is generally allowed to be equal in bulk to the one-thoufandth part of the cubic foot. Were 44.3511 parts out of 10000, or about $\frac{1}{225}$th part added to the prefent Winchefter bufhel, that bufhel would then contain exaĉtly 10 cubic feet or 10000 oz. of diftilled water, at 60° of heat.

Our author then gives comparative tables between this fyftem and that which is now eftablifhed in France. Taking the metre at 3 French feet, and 11.296 lines †, and the French foot to be to the Englifh as 1 : 1.065752004 ‡, one French foot will be equal to 10.65752004 Englifh decades, or tenths of an Englifh foot: hence he calculates the following

† *Journal de Phyf.* vol. v. p. 460.

‡ *Phil. Tranf.* 1768, p. 326, and *Connoiffance des Temps*, 1795.

COMPARATIVE TABLES, Englifh with French.

LONG MEASURE.

Long decade.	Metre.	Metre.	Long decades.
1 =	0.03047983 fere	1 =	32.808583358, &c. or inches 39.3703.

SQUARE MEASURE.

Square decades.	Ares,	Ares,	Square decades.
1 =	0.0000092902 fere	1 =	107640.3142, or fqr. inch. 155002.052448

CUBE MEASURE.

Cube decades.	Litres.	Litre.	Cube decades.
1 =	0.02831637 fere	1 =	35.3152622, &c. or cub.inch. 61.0247727

WEIGHTS.

WEIGHTS.

Avoird. or decade oz.	Grammes	Gramme.	Decade oz.
1	= 28.31637 fere	1 =	0.03531526, &c. or grains, 15.45042625

Long, Square, or Cube, decades are reduced to Long, Square, or Cube, English inches by multiplying by 1.2, 1.44, 1.728; and decade ounces are reduced to grains, containing 7000, or 5760, to the lb. Avoird. Troy, by multiplying the ounce by $437.5 =$ the number of grains in an avoirdupoise ounce.

Our author, who feems to have paid much attention to weights and meafures, obferves, that a ftandard meafure for the purpofes of trade, in particular, as well as for others, that would uniformly give an accurate refult, and could be eafily made, examined, and afcertained, by common mechanics, which neither our prefent liquid nor dry meafures evidently can, would furely be an acquifition of great value. Such an one, he prefumes, would be the following: A fquare pyramid, whofe perpendicular height is exactly thrice the length of the fide of the bafe: for fuch an one, and every fection of it, made by a plane parallel to its bafe, would, in the firft inftance, poffefs, and, in every fubdivifion, retain thefe remarkable properties.

1ft, Similar comparative dimenfions to thofe above given, for the original pyramid, *i. e.* every fmaller pyramid, formed by the above-mentioned parallel fection, would have its perpendicular height thrice the length of the fide of its bafe; and,

2dly, The length of the fide of each bafe will always indicate, or equal the cube root of the folid content of the pyramid; *e. g.* If the length of the fide of the bafe be 3, the folid content will be the cube of 3, *viz.* $3 \times 3 \times 3 = 27$.

We do not perceive very clearly the great value of this ftandard; but Mr Goodwyn fays, that he has been many years in the habit of ufing a pyramid meafure to examine corn; and is perfectly convinced that fuch a one will indicate a far more accurate refult than can arife from the manner in which corn is meafured by the bufhel. This we are bound to believe; for it is abfurd to oppofe theories to a fact afcertained by experience.

WESTRINGIA, a new genus of plants defcribed by J. E. Smith, M. D. prefident of the Linnæan Society of London. It was firft difcovered in New Holland by Dr Solander, who called it *Cunila Fruticofa*, though it is totally different from the CUNILA (fee that article, *Encycl.*), and more refembles rofemary, from which, however, it is likewife different. Its peculiar character is: *Calyx femiquinquefidus, pentagonus; corolla refupinata, limbo quadrifido, lobo longiore erecto, bipartito: Stamina diftantia, duo breviora (inferiora) abortiva.* Dr Smith affigns it rather to the *didynamia-angiofpermia*, placing it immediately after the *Teucrium*, than to the *diandria* clafs of plants.

WHEAT (fee TRITICUM, *Encycl.*) has for fome years paft been at fo very high a price, that every hint for increafing its quantity or improving its quality is intitled to notice. In the Leicefter Journal for the 6th of December 1799, there is an ingenious paper on the fubject of tranfplanting wheat, as a means of providing againft the expected fcarcity of that neceffary of life. It is recommended "to fow, in dry land, at the ufual feafon, as much corn as may be deemed neceffary to plant in the fpring any number of acres which may be occupied with that article in the following year. When the foil is prepared, a furrow is to be made with a very fmall plough and one horfe, in the centre of the ridge or land, returning back in the fame track (this time only of every ridge); then turn towards the left hand, and plough another furrow, about eight or nine inches from the firft furrow, turning always to the left hand, till the whole ridge is finifhed; it will then be formed into trenches, in parallel lines, of about eight or nine inches afunder, and imitate what gardeners term drawing of drills. In thefe furrows the plants are to be laid." Mr John Ainfworth of Glen, the experienced author of this communication, fays he has practifed this method with the moft complete fuccefs.

It has been likewife practifed, on a fmall fcale, with equal fuccefs, but we know not in what county. About the end of Auguft 1783, that gentleman threw a fmall quantity of wheat, which near two years before had been fteeped and limed (fee WHEAT, *Encycl.*) into an unmanured corner of his garden. In the beginning of February following he had a piece of ground (alfo unmanured) dug in an open part of his orchard, and he tranfplanted it on beds of fix rows wide, at nine inches afunder every way. It tillered, and fpread over the ground fo completely, as to prevent even a weed growing among it. It produced admirable corn, and at the rate of near four quarters per acre.

From accurate calculations which he then made, he found that an acre, fuppofing the feed to be very good, and the plants fet at the diftance above mentioned, would require only *half a peck* of feed.

Befides the faving of the feed, there are two other material advantages which attend fuch a method; one is, that fome fuitable crop may be on the ground all the winter for ufe; and the other is, that ploughing the ground fo late as February, will effectually bury and deftroy thofe weeds which were beginning to vegetate; and before others can fpring up, the corn plants have taken to the ground, and fo fpread over it that the weeds cannot rife, by which means there is a very clean crop, and all the cuftomary expence for weeding is faved.

This author feems to think that wheat will thrive as well, and produce as full a crop, when fown in the fpring, as if it had been committed to the ground in the preceding autumn. In the fouthern counties of England we doubt not but it may; but the cafe is otherwife in Scotland, where the fpring is not fo early, and where, from the narrownefs of the ifland, the froft is feldom fo fevere. We agree, however, with Dr Pike, in thinking it a pity that the way of fetting wheat (as done in Norfolk and Suffolk) is not every where more general. The procefs is indeed tedious and troublefome; and we have often wondered that, among the numberlefs machines lately contrived to leffen manual labour, none has been invented for dibbling wheat expeditioufly and accurately. We are therefore pleafed to learn, that Dr Pike himfelf has turned his attention to the fubject, and hopes in the courfe of this year (1800) to prefent the public with a *method of fetting wheat*

wheat at PERFECTLY EXACT *distances through a whole field, and as* EXPEDITIOUSLY *as the common broadcast sowing, which can therefore be applied to forms of any magnitude*; and when a peck of seed is found to be sufficient for an acre (and in some land much less), the saving on a large farm must be immense. We trust to the liberality of his profession, that he will not take out a patent for his invention.

Though we have elsewhere given the usual recipes for preventing smut in wheat, it would be improper to conclude this article without mentioning the very simple one which Mr Wagstaffe of Norwich has uniformly found attended with complete success. This consists in nothing more than immersing the seed in pure water, and repeatedly scouring it therein, just before it is sown or dibbled in the soil. Whether well, spring, or river water be used, is indifferent; but repeated stirring and change of water is essential to remove the particles of infection that may have imperceptibly adhered to the seeds thus purified The subsequent crop will be perfect in itself, and its seeds, he says, successively so likewise, if there are no adjacent fields from whence this contamination may be wafted. He recommends the same washing, and for the same reason, of barley and oats before they be sown.

WILKIE (William, D. D.), the author of an heroic poem, intitled the *Epigoniad*, was born in the parish of Dalmeny, in the county of West-Lothian, on the 5th of October 1721. He was descended of an ancient family in that county, though his father rented only a small farm, and was poor and unfortunate through life. He was able, however, to give his son a liberal education; and that son, it is said, discovered so early a propensity to the study of poetry, that he began to write verses in his tenth year.

As this wonderful prematurity of genius was never heard of during Wilkie's life, it will probably be considered as a story fabricated to raise the Scottish poet to the same eminence with Pope, whose versification he is allowed to have imitated with success. We have no doubt but that Wilkie wrote in early life the description of a storm, which is published in the 9th volume of the Statistical Account of Scotland; but that he wrote it in his tenth year is not proved, and is highly improbable. The poem displays a notion—a confused notion indeed—of the laws of electricity, which a boy in his tenth year, and at a period when electricity was little understood, could not have acquired.

Having learned the rudiments of the Latin tongue at the parish-school of Dalmeny, young Wilkie was, at the age of thirteen, sent to the university of Edinburgh, where he was soon distinguished by his originality of thought, and by his rapid progress in erudition and science. Among his fellow-students he was most closely associated with Dr Robertson the historian, Mr John Home the poet, Dr M'Ghie(A), who afterwards obtained the friendship of Johnson, and became a member of the Ivy-lane Club; and a Mr Cleghorn, who promised be an ornament to the university, in which he was afterwards a professor, but died before he had time to realize the fond hopes of his friends. During the course of his education, Wilkie became acquainted with the celebrated David Hume and Dr Ferguson, and at a later period with Dr Adam Smith, the far-famed author of "The Wealth of Nations." Of all those men he regarded Dr Ferguson with the greatest affection, and Dr Smith with the greatest admiration. This last writer he considered as equal to Robertson and Hume in erudition, and vastly their superior in originality and invention; and this opinion he cherished to the day of his death.

Before he had completed his education, his father died, leaving him no other inheritance than the stock and unexpired lease of his farm, and the care of his three sisters. Wilkie, therefore, turned much of his attention to agriculture, in which he became eminent, not merely as a theorist, but as a practical farmer. He had too much science to be the slave of ancient prejudice, and too much judgment to be hurried into hazardous experiments by the charms of untried speculation. One of his sisters being married to a skilful, though unlettered farmer, he availed himself of his brother's experience; and upon the facts and maxims derived from him built a system of practical farming, which fully answered his own expectation, and obtained the applause of all his neighbours.

He still prosecuted his studies in the university, and without ceasing to be a farmer became a preacher in the church of Scotland. For some years this made no alteration in the mode of his living. He preached occasionally for the ministers in his neighbourhood; cultivated his farm; read the classics; and, enamoured of the simple sublimity of Homer, projected an epic poem on the Homeric model. The subject of his intended poem he drew from the fourth book of the *Iliad*, where Sthenelus gives Agamemnon a short account of the sacking of Thebes; and as that city was taken by the sons of those who had fallen before it, Wilkie gave to his poem the quaint title of *Epigoniad*, from the Greek word επιγονοι which signifies *descendants*. It is not our business to write a criticism upon this poem. The subject was ill-chosen; for the learned reader has enough of the heroic ages in the immortal poems of Homer and Virgil, and in those ages the unlearned reader can feel no interest. The Epigoniad, therefore, though composed in smooth and elegant verse, with due attention to ancient manners, and constructed on the most regular plan, has fallen into neglect, from which no critic or biographer will ever rescue it.

In the year 1753, Mr Wilkie was ordained minister of Ratho, in consequence of a presentation from the Earl of Lauderdale, who knew his worth and admired his genius. Without neglecting his favourite amusements of husbandry, or the study of the belles lettres, he discharged with fidelity the duties of a Christian pastor, was famed for his original and impressive mode of preaching,

(A) According to Sir John Hawkins, this man bore arms on the side of government at the battle of Falkirk 1745. After which, taking a degree in physic, he went to London in hopes of employment through the interest of his countrymen, and perhaps in return for his loyalty. He was a learned, ingenious, and modest man; but so little successful in his profession, that he died of a broken heart, and was buried by a contribution of his friends.

Wilkie.

preaching, and soon came to be loved as well as esteemed by his rural flock.

In the year 1757 the Epigoniad was published, the result of fourteen years study and application, which might surely have been more usefully employed on some other work; and in 1759 a second edition was called for, to which he added *A Dream in the manner of Spenser*. He was, the same year, chosen professor of natural philosophy in the university of St Andrew's; an office for which it is difficult to conceive how he could have been fitted by the study of epic poetry, and close attention to the cultivation of his farm. He was, however, a man of a vigorous mind, and we never heard that he disgraced his electors.

When he removed to St Andrew's, his whole fortune exceeded not L. 200 Sterling; a proof that his Epigoniad had not enriched him. With this sum he purchased a few acres of land in the neighbourhood of the city, carried his two unmarried sisters with him, and continued to live in the university exactly as he had lived at Ratho. In his professorial career there was nothing remarkable. He patronised genius, especially poetical genius, in the young men who attended his lectures, and by them was, of course, loved and esteemed: (See FERGUSSON in this *Suppl.*) In the year 1768 he published a volume of fables of no great value, previous to which the university conferred upon him the degree of D. D.; and he died, after a lingering illness, on the 10th of October 1772.

The manners of Dr Wilkie were singular, and in some respects disgusting. He has been severely blamed for his penuriousness, but, in our opinion, unjustly. His father had left him in debt, with nothing but the profits which he might make of a small farm to discharge that debt, and to support himself and three sisters. In him, therefore, rigid economy was, for many years, a virtue; and he knows little of human nature, who can blame a man for not breaking habits which it had been the duty, as well as the business, of a great part of his life to form. Amidst his most rigid and offensive economy, he was liberal in his donations to the poor.

He had been seized, while minister of Ratho, with an unformed ague, of which he never got entirely rid. For this complaint he thought an extraordinary perspiration necessary, and generally slept, in winter, under twenty-four blankets. He had an utter aversion from clean linen, and has been known to bargain, when he staid a night from home, not only for the proper quantity of blankets to his bed, but also for sheets, which had been used by some other person, and rendered sufficiently dirty to please his feeling. It will easily be conceived that such a man was, to the last degree, slovenly in his dress.

Suspicions have been thrown out by his latest, and we believe his only, biographer, that Dr Wilkie's belief of the Christian religion was neither orthodox nor steady. Not having had the pleasure of his acquaintance, we cannot positively say that these suspicions are groundless; but the writer of this article has conversed much about the author of the Epigoniad with a clergyman who knew him well, and who would have been glad to accuse him of infidelity, if he could have preferred such an accusation with truth. He was a very absent man, apt to forget what he was about even when discharging the most solemn parts of his clerical duty, and used to say of himself that he never could conduct a sacrament. From this absence of mind, and those confessions of it, may have arisen the suspicion that he was not a firm believer; but no such suspicion was ever thrown out to this writer by the clergyman already referred to.

He had one very extraordinary defect in a poet: He could not read aloud the smoothest verses, so as to preserve either the measure or the sense of them. Of this Dr Anderson has produced very complete proof in his life of Wilkie, prefixed to his poetical works in the Edinburgh edition of the British Poets. With all his defects, however, and all his foibles, he was unquestionably a genius, and, we are inclined to believe, a good man.

Wines, Wood-cuts.

WINES (see that article, *Encycl.* and *Vegetable Substances, Suppl.*) are so often adulterated with minerals prejudicial to the health, that various methods have been devised for detecting the adulteration. The property which liver of sulphur (alkaline sulphures) and hepatic air (sulphurated hydrogen) possess of precipitating lead in a black form, has been long ago made public; and this property has been employed to determine the quality of wines by means of the *liquor probatorius Wirtembergensis*, or Wirtemberg proving liquor. But in trying wines supposed to have been adulterated, this proof does more hurt than service, because it precipitates iron of the same colour as the pernicious lead. Many wine-merchants, therefore, of the greatest respectability, rendered by these means suspected, have been ruined.

The following is recommended by M. Hanhemann as a better test of sound wines than the proving liquor of Wirtemberg. Mix equal parts of oyster shells and crude sulphur in a fine powder, and put the mixture into a crucible. Heat it in a wind furnace, and increase the fire suddenly, so as to bring the crucible to a white heat, for the space of 15 minutes. Pulverise the mass when it is cool, and preserve it in a bottle closely stopped.

To prepare the liquor, put 120 grains of this powder, and 120 grains of cream of tartar (acidulous tartarite of potash), into a strong bottle; fill the bottle with common water, which boil for an hour, and then let it cool; close the bottle immediately, and shake it for some time: after it has remained at rest to settle, decant the pure liquor, and pour it into small phials capable of holding about an ounce each, first putting into each of them 20 drops of muriatic acid. They must be stopped very closely with a piece of wax, in which there is a small mixture of turpentine.

One part of this liquor, mixed with three parts of suspected wine, will discover, by a very sensible black precipitate, the least traces of lead, copper, &c. but will produce no effect upon iron, if it contains any of that metal. When the precipitate has fallen down, it may still be discovered whether the wine contains iron, by saturating the decanted liquor with a little salt of tartar (tartareous acidulum of potash), by which the liquor will immediately become black. Pure wines remain clear and bright after this liquor has been added to them.

WOOD-CUTS are engravings on wood, commonly on

Wood-cuts. on box, which, in many cafes, are ufed with advantage inftead of copper-plates. The art of cutting or engraving on wood is undoubtedly of high antiquity; for Chinefe printing is a fpecimen of it. (See CHINA, n° 127 *Encycl.*) Even in Europe, if credit be due to Papillon, this art was practifed at a period confiderably remote; for he mentions eight engravings on wood, entitled, "A reprefentation of the warlike actions of the great and magnanimous Macedonian king, the bold and valiant Alexander; dedicated, prefented, and humbly offered, to the moft holy father, Pope Honorius IV. by us Alexander Alberic Cunio Chevalier, and Ifabella Cunio, &c." This anecdote, if true, carries the art of cutting in wood back to 1284 or 1285; for Honorius occupied the papal throne only during thefe two years. Even this is not the remoteft period to which fome have carried the art in Europe; for the ufe of feals or fignets being of very high antiquity, they imagine that the invention of wood-cuts muft be coeval with them. The fuppofition is certainly plaufible, but it is not fupported by proof. The earlieft impreffion of a wooden-cut, of which we have any certain account, is that of St Chriftopher carrying an infant Jefus through the fea, in which a hermit is feen holding up a lantern to fhew him the way; and a peafant, with a fack on his back, climbing a hill, is exhibited in the back ground. The date of this impreffion is 1423.

In the year 1430 was printed at Haarlem, "The hiftory of St John the evangelift and his revelation, reprefented in 48 figures in wood, by Lowrent Janfon Cofter;" and, in 1448, Jorg Schappf of Augfburg cut in wood the hiftory of the Apocalypfe, and what was called *The poor man's bible*. (See ENGRAVING, *Encycl.* page 668.)

A folio chronicle, publifhed 1493 by Schedal, was adorned with a vaft number of wood-cuts by William Plydenwurf and Michael Wolgemut, whofe engravings were greatly fuperior to any thing of the kind which had appeared before them. Wolgemut was the preceptor of Albert Durer, whofe admirable performances in this department of art are juftly held in the higheft efteem even at the prefent day.

About this period it became the practice of almoft all the German engravers on copper to engrave likewife on wood; and many of their wood cuts furpafs in beauty the impreffion of their copper-plates. Such are the wood-cuts of Albet Aldtorfer, Hifbel Pen, Virgil Soles, Lucas van Cranach, and Lucas van Lyden, the friend and imitator of Albert Durer, with feveral others.

It appears that the Germans carried this art to a great degree of perfection. Hans or John Holbien, who flourifhed in 1500, engraved the *Dance of Death*, in a feries of wooden-cuts, which, for the freedom and delicacy of execution, has hardly been equalled, and never furpaffed.

Italy, France, and Holland, have produced many capital artifts of this kind. Joan Tornæfium printed a bible at Lyden, in 1554 (a copy of which we have feen), with wooden-cuts of excellent workmanfhip. Chriftopher Jegher of Antwerp, from his eminence in the art, was employed by Rubens to work under his infpection, and he executed feveral pieces which are held in much eftimation; the character of thefe is boldnefs and fpirit.

The next attempt at improvement in this art was by Hugo da Carpi, to whom is attributed the invention of the *chiara fcuro*. Carpi was an Italian, and of the 16th century; but the Germans claim the invention alfo, and produce in evidence feveral engravings by Mair, a difciple of Martin Shoen, of date 1499. His mode of performing this was very fimple. He firft engraved the fubject upon copper, and finifhed it as much as the artifts of his time ufually did. He then prepared a block of wood, upon which he cut out the extreme lights, and then impreffed it upon the print; by which means a faint tint was added to all the reft of the piece, excepting only in thofe parts where the lights were meant to predominate, which appear on the fpecimens extant to be whitened with white paint. The drawings for this fpecies of engraving were made on tinted paper with a pen, and the lights were drawn upon the paper with white paint.

There is, however, a material difference between the *chiaro fcuros* of the old German mafters and thofe of the Italians. Mair and Cranach engraved the outlines and deep fhadows upon copper. The impreffion taken in this ftate was tinted over by means of a fingle block of wood, with thofe parts hollowed out which were defigned to be left white upon the print. On the contrary, the mode of engraving by Hugo da Carpi was, to cut the outline on one block of wood, the dark fhadows upon a fecond, and the light fhadows, or half tint, upon a third. The firft being impreffed upon the paper, the outlines only appeared: this block being taken away, the fecond was put in its place, and being alfo impreffed on the paper, the dark fhadows were added to the outlines; and the third block being put in the fame place upon the removal of the fecond, and alfo impreffed upon the paper, made the dim tints, when the print was completed. In fome inftances, the number of blocks were increafed, but the operation was ftill the fame, the print receiving an impreffion from every block.

In 1698, John Baptift Michel Pappillon practifed engraving on wood with much fuccefs, particularly in ornamental foliage and flowers, fhells, &c. In the opinion, however, of fome of the moft eminent artifts, his performances are ftiff and cramped. From that period the art of engraving on wood gradually degenerated, and may be faid to have been wholly loft, when it was lately re-invented by Mr Bewick of Newcaftle.

This eminent artift was apprentice to Mr Bielby, an engraver on metal of the very loweft order, who was feldom employed in any thing more difficult than the cutting of the face of a clock. Application having been made to this man for a wood-cut or two of the moft trifling defcription, the job was given to Thomas Bewick; by whom it was executed in fuch a manner, that Mr Bielby, who was accuftomed to employ his apprentices in fuch work, advifed him to profecute engraving in that line. The advice was followed; and young Bewick inventing tools, even making them with his own hands, and fawing the wood on which he was to work into the requifite thicknefs, proceeded to improve upon his own difcoveries, without affiftance or inftruction of any kind. When his apprenticefhip expired, he went to London, where the obfcure wood-engravers of the time wifhed to avail themfelves of his abilities, while they were determined to give him no infight

into

into their art. He remained ſome years in London; and during that time, if we miſtake not, received from the *Society for the Encouragement of Arts, &c.* a premium of conſiderable value for the beſt engraving in wood. Returning to Newcaſtle, he entered into copartnerſhip with his old maſter; and eſtabliſhed his reputation as an artiſt by the publication of his admirable Hiſtory of Quadrupeds. This was followed by his Hiſtory of Birds, of which only one volume has yet (1800) appeared.

John Bewick, brother to Thomas, learned the art of him, and practiſed it for ſeveral years in London with great applauſe. His abilities, however, though reſpectable, were not, by the beſt judges, deemed ſo brilliant as his brother's; and owing to bad health, and the nature of his connection with the bookſellers and others, he ſeems not to have advanced the art beyond the ſtage at which he received it. He died, three or four years ago, at Newcaſtle.

Mr Neſbit, who executed the admirable Hudibras publiſhed by Vernor and Hood (A), and Mr Anderſon, whoſe beautiful cuts adorn the poem entitled *Grove Hill*, were the next, and hitherto have been the laſt of Thomas Bewick's pupils, who have appeared before the public as artiſts. By theſe gentlemen we are authoriſed to ſay, that the method practiſed by the ancient engravers on wood, whoſe works are ſtill admired, muſt have been different from that of Bewick and his pupils. What that method was ſeems to be altogether unknown. Papillon, who writes the beſt hiſtory extant of the art, gueſſes indeed in what manner the old engravers proceeded ſo as to give their works the ſpirit and freedom for which they are famed; but that his gueſſes are erroneous ſeems evident from the ſtiffneſs of his own works. The principal characteriſtic in the mechanical department of the productions of the ancient maſters is the croſſing of the black lines, which Papillon has attempted with the greateſt awkwardneſs, though it ſeems to have been accompliſhed by them with ſo much eaſe, that they introduced it at random, even where it could add nothing to the beauty of the piece. In Bewick's method of working, this croſs hatching is ſo difficult and unnatural, that it may be conſidered as impracticable (B).

The engravers of Bewick's ſchool work on the end of the wood which is cut acroſs the trunk of the tree, in pieces of the proper thickneſs. As wood-cuts are generally employed in the printer's preſs amidſt a form of types, this thickneſs muſt be regulated by the height of the types with which they are to be uſed. The tools employed are nearly the ſame with thoſe uſed in copperplate engraving, being only a little more deep, or lozenge, as engravers call it. They muſt have points of various degrees of fineneſs for the different purpoſes to which they are applied, ſome of them being ſo much rounded off at the bottom as to approach to the nature of a goodge, whilſt others are in fact little chiſſels of various ſizes. Theſe chiſſels and goodges, to which every artiſt gives the ſhape which he deems moſt convenient, are held in the hand in a manner ſomewhat different from the tool of the engraver on copper, it being neceſſary to have the power of lifting the chips upwards with eaſe. To attempt a deſcription of this in writing would be in vain; but it is eaſily acquired, we are told, by practice.

The pupils of the ſchool of Bewick conſider it as quite improper to ſpeak of his invention as a revival of the ancient art. Some old prints, it is true, have the appearance of being executed in the ſame way with his; but others have certainly been done by a method very different. It is therefore not fair to appreciate the preſent art by what has been done, but by what may be done; and that remains yet to be ſhewn. The art is in its infancy; and thoſe who are diſpoſed to compare it with the art of engraving on copper, ought to look back to the period when the copperplate engraving was of ſo recent invention as Bewick's method of engraving on wood. Marc Antonio, who engraved under the direction of the great painter Raphael, thought it no mean proof of his proficiency in his art, that he was able to imitate on copper-plates the wood-cuts of Albert Durer; and Papillon is highly indignant that there ſhould have been perſons ſo very blind as to miſtake the copies for the originals. If copper has its advantages over wood in point of delicacy and minuteneſs, wood has, in its turn, advantages not inferior in regard to ſtrength and richneſs. Thoſe prints which were executed under the auſpices of Titian and Rubens, will always remain a monument of the ſpirit and vigour natural to wood engraving; and if there be not found in them all the attention to *chiaro ſcuro*, which the preſent age demands, it muſt not be attributed either to defect in the art, or to want of abilities in the artiſts, but to the taſte of the times when *chiaro ſcuro* was little underſtood. It remains for ſome enterpriſing artiſt to ſhew that the vigour of the ancient art may be attained by the preſent one, and at the ſame time to add to that vigour thoſe gradations of ſhade which are ſo much admired in good copperplates. As there ſeems to be a more perfect, or at leaſt a more pleaſant black produced by a wood than by copperplate printing, and certainly a more perfect white (C), who will ſay that any intermediate ſhade whatever may not be produced by wood-cuts? To attempt this on a ſmall ſcale would indeed be vain, becauſe the ſlighteſt variation, produced by a little more or leſs ink, or a harder preſſure in printing, bears ſuch a proportion to a very ſhort line, as muſt neceſſarily render the attempt abortive.

Wood-engraving, therefore, muſt always appear to diſadvantage while it is confined to ſmall ſubjects, and will never reach its ſtation *as a fine art*, till thoſe who are engaged in its cultivation improve upon the diſcoveries of one another, and apply to ſubjects to which it is properly adapted. As an *economical art* for illuſtra-

 ting

(A) The deſigns were by Thornton; and the cuts from them have been compared to Holbein's far-famed Dance of Death.

(B) Mr Neſbit has indeed introduced ſomething of it into two or three of his pieces, merely to ſhew that he *could* do it; but ſo great was the labour, and ſo little the advantage of this improvement, if ſuch it can be called, that probably it will not be attempted again.

(C) The parts of the print intended to be white are not even touched by the wood-block.

Wool-combing. ting mechanics and other ſubjects of ſcience, it is too little employed even in its preſent ſtate.

The works of Bewick and his pupils, which have hitherto been publiſhed, are not numerous. Beſides his quadrupeds and birds, the Hudibras by Neſbit, and the Grove Hill by Anderſon, which have been already noticed, we are acquainted with none but the following :—Goldſmith's *Traveller* and *Deſerted Village* with elegant plates, all by Thomas Bewick, except one or two which were executed by John ; Somerville's *Chace* by the ſame artiſts, executed in a ſtyle of elegance which perhaps has never been ſurpaſſed ; a View of St Nicholas's Church, Newcaſtle, 15 inches long, by Mr Neſbit, who received for it a ſilver medal from the Society for the Encouragement of Arts, and an honorary letter from the Society of Antiquaries.

WOOL-COMBING, a well known operation, which, when performed by the hand, is laborious, tedious, and expenſive. The expence of it through all England has been calculated at no leſs a ſum than L. 800,000 ; and to leſſen this expence, the Rev. Edmund Cartwright of Doncaſter in Yorkſhire bethought himſelf, ſome years ago, of carding wool by machinery. After repeated attempts and improvements, for which he took out three patents, he found that wool can be combed in perfection by machinery, of which he gives the following deſcription :

Plate L. Fig. 1. Is the crank laſher. A is a tube through which the material, being formed into a ſliver, and ſlightly twiſted, is drawn forward by the delivering rollers. B, a wheel faſt upon the croſs-bar of the crank. C, a wheel, on the oppoſite end of whoſe axis is a pinion working in a wheel upon the axis of one of the delivering rollers.

Note, When two or more ſlivers are required, the cans or baſkets, in which they are contained, are placed upon a table under the laſher (as repreſented at D), which, by having a ſlow motion, twiſts them together as they go up.

Fig. 2. Is the circular clearing comb, for giving work in the head, carried in a frame by two cranks. Fig. 3. The comb-table, having the teeth pointed towards the centre, moved by cogs upon the rim, and carried round upon trucks, like the head of a windmill. *a*, *b*, the drawing rollers. *c*, *d*, callender, or conducting rollers.

Note, Underneath the table is another pair of rollers, for drawing out the backings.

In the above ſpecification, we have omitted the frame in which the machine ſtands, the wheels, ſhafts, &c. Had theſe been introduced, the drawing would have been crowded and confuſed ; beſides, as matters of information, they would have been unneceſſary, every mechanic, when he knows the principles of a machine, being competent to apply the movements to it.

The wool, if for particular nice work, goes through three operations, otherwiſe two are ſufficient : the firſt operation opens the wool, and makes it connect together into a rough ſliver, but does not clear it. The clearing is performed by the ſecond, and, if neceſſary, a third operation. A ſet of machinery, conſiſting of three machines, will require the attendance of an overlooker and ten children, and will comb a pack, or 240 lb. in twelve hours. As neither fire nor oil is neceſſary for machine-combing, the ſaving of thoſe articles, even the fire alone, will, in general, pay the wages of the overlooker and children ; ſo that the actual ſaving to the manufacturer is the *whole* of what the combing coſts, by the old imperfect mode of hand-combing. Machine-combed wool is better, eſpecially for machine-ſpinning, by at leaſt 12 *per cent.* being all equally mixed, and the ſlivers uniform, and of any required length.

Y.

Yeaſt. YEAST, is ſometimes a deſideratum, when it cannot eaſily be found. By pouring on a ſmall tea-cupful of ſplit peas a pint of boiling water, and ſetting the veſſel containing the peas and water for a night on the hearth or any warm place, a froth will in the morning be found on the top of the water, which, we are aſſured, will anſwer all the purpoſes of yeaſt.

Z.

Zaminy. ZAMINY, in the language of Bengal, ſecurity.

Zemindars. ZEMINDARS, the great landholders of Bengal. This is the original ſenſe of the word ; but it is now more ſtrictly applicable to thoſe who have their title conſtituted or confirmed by a patent or charter from government, by which they hold their lands or Zemindaries upon certain conditions. As far as can be aſcertained from the narrations of hiſtory, it appears that, in times prior to the irruptions of the Mahomedans, the Rajahs who held their reſidence at Delhy, and poſſeſſed the ſovereignty of Hindoſtan, deputed officers to collect their revenues (Kherâje), who were called in the Indian language

WATCH WORK, PLATE XLVIII.

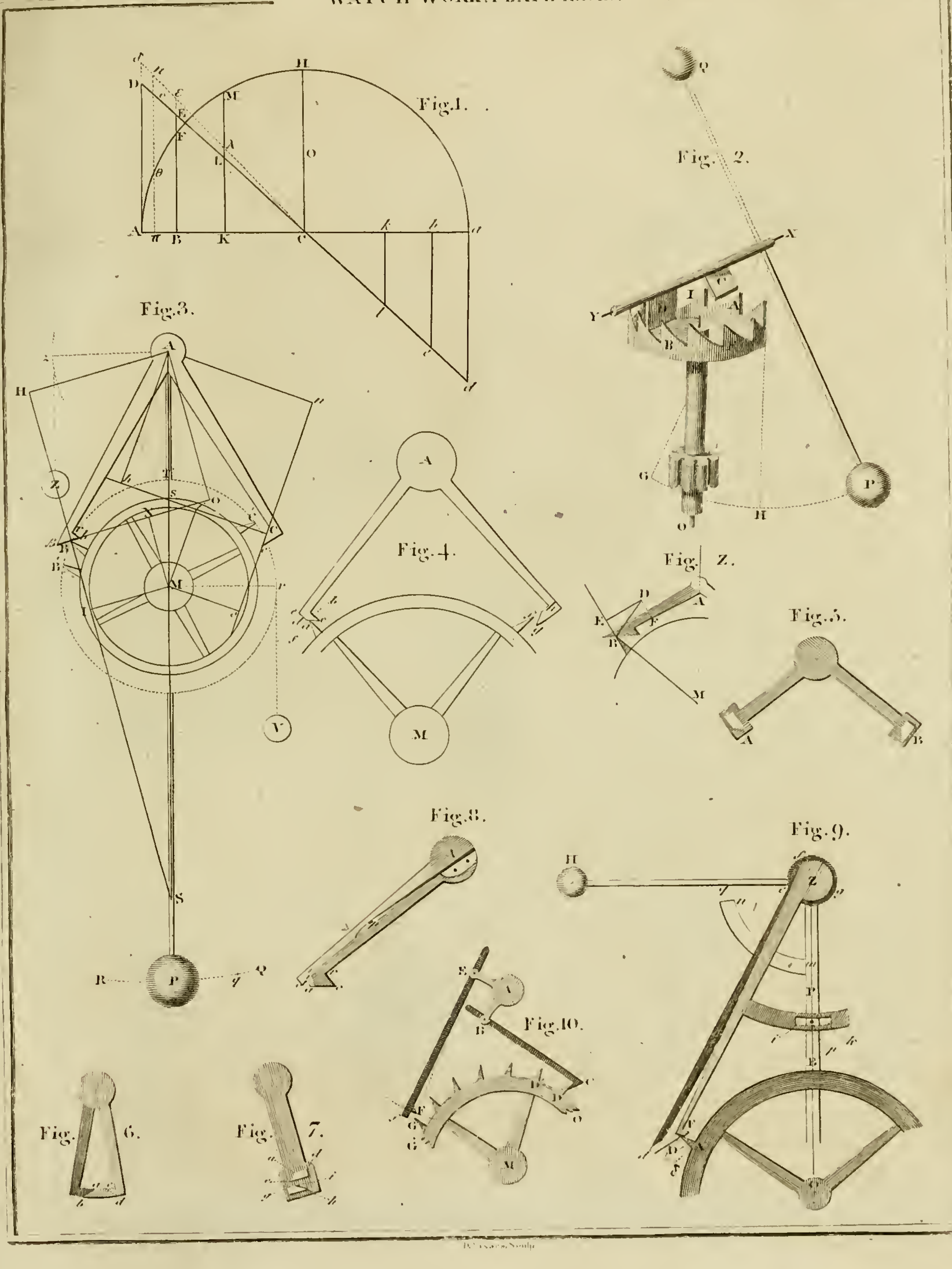


Fig. 11.

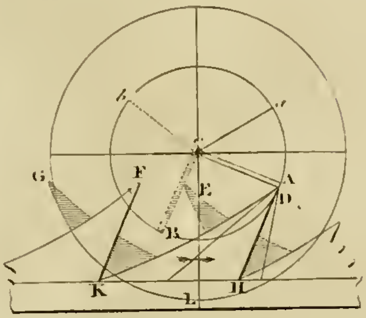


Fig. 12.

Fig. 13.

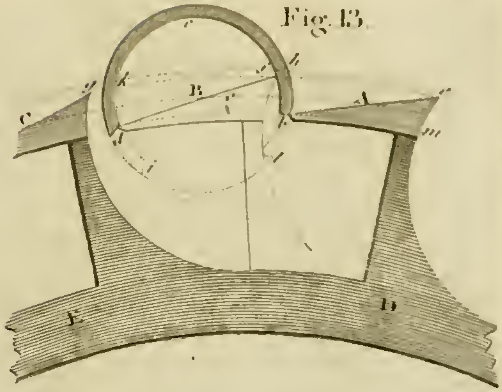


Fig. 14.

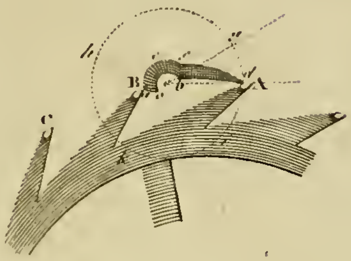


Fig. 15.

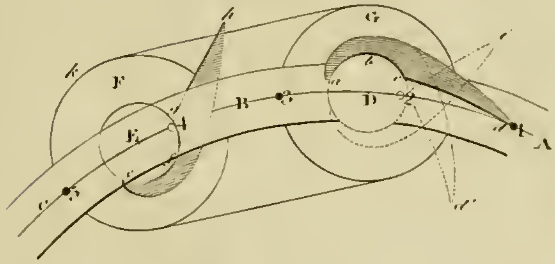


Fig. B. 15.

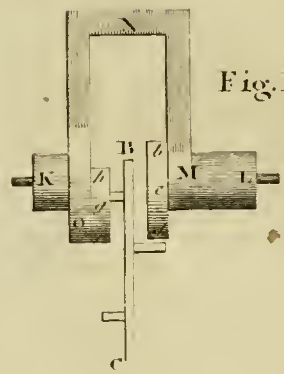


Fig. B. 13.

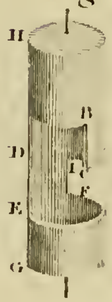


Fig. C.

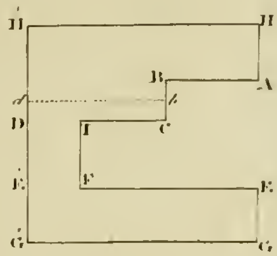


Fig. 19.

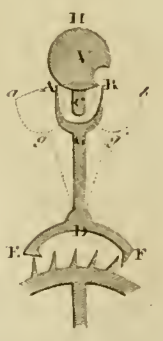


Fig. 16.

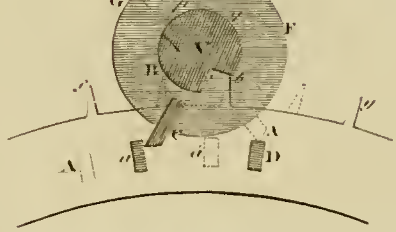


Fig. 17.

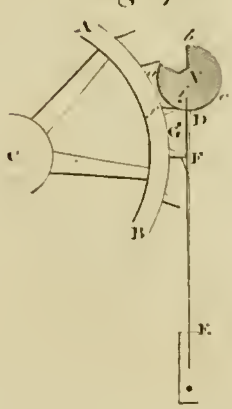
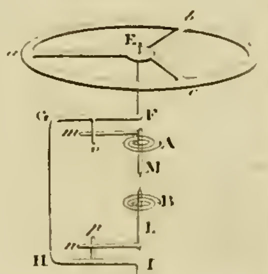
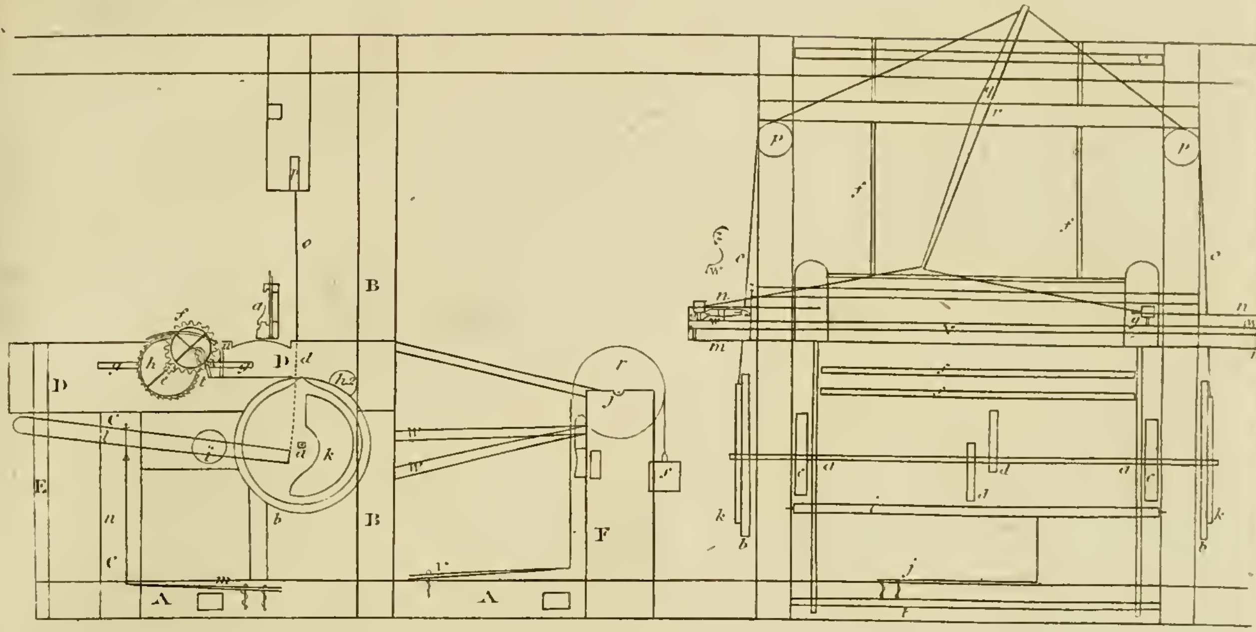


Fig. 18.



D. Lizars Sculp.

Fig.1. Fig.2.



WOOL-COMBING

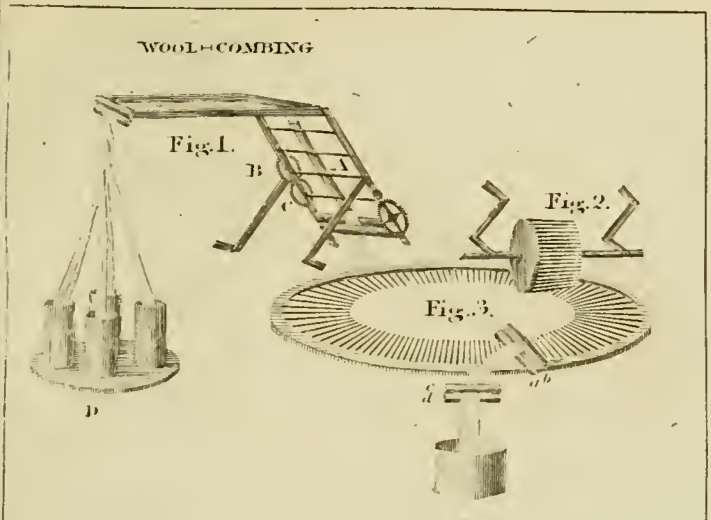
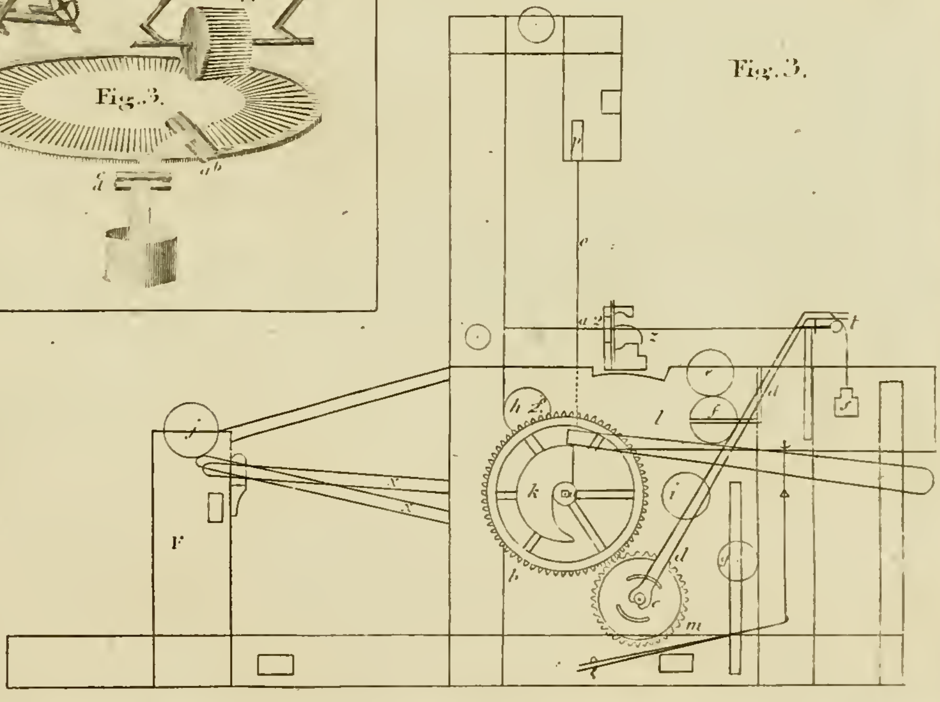


Fig.3.



Zemindars. language *Choudheries*. The word *Zemindar* is Persian, and that language can have had no currency in the countries of India, until it was introduced by the people of Persia. When the Emperor Shehâb-ul-Dien Ghory conquered the empire of Hindostan (A), he left Sultan Cutub-ul-Dien to be his viceroy at Delhy, and administer the government of Hindostan. From that time the customs and practices of the Mahomedans began gradually to be established in India: their armies were sent into the countries of the reduced Rajahs, under the command of Omrahs, in order to preserve the conquest; and lands were allotted to them to defray the expence. From hence arose the system of Jaghiredarry in Hindostan. But when these Omrah Jaghiredars had established their own strength, several of them rebelled against the imperial authority, and aspired at the crown. Thus circumstanced, the emperors, in order to obviate these mischiefs, thought it would be more politic to commit the management of the country to the native Hindoos, who had most distinguished themselves by the readiness and constancy of their obedience to the sovereign power.

In pursuance of this plan, districts were allotted to numbers of them under a reasonable revenue (Jummah Monâsib), which they were required to pay in money to the governors of the provinces, deputed from the Emperor. And in case any one of the Omrahs or provincial governors should swerve from his allegiance, the Zemindars of that country were to exert themselves in such a manner as should check rebellion, and restore good government. For this purpose, grants of Zemindary were severally conferred upon such of the Hindoos as were obedient; describing their apportionment of the country; and every person who had received a grant under the authority of the crown was thereby fully invested with the functions of Zemindar.

The functions of a Zemindar are, 1st, The preservation and defence of their respective boundaries from traitors and insurgents; 2dly, The tranquillity of the subjects, the abundance of cultivators, and increase of his revenue; 3dly, The punishment of thieves and robbers, the prevention of crimes, and the destruction of highwaymen. The accomplishment of these objects is considered in the royal grant as the discharge of office to the sovereign; and on that account the word *office* (Khidmut) is employed in the Dewanny Sunnud for a Zemindary.

It was a rule in the times of the ancient emperors, that when any of the Zemindars died, their effects and property were sequestrated by the government. After which, in consideration of the rights of long service, which is incumbent on sovereigns, and elevates the dignity of the employer, Sunnuds for the office of Zemindary were granted to the children of the deceased Zemindar; and no other person was accepted, because the inhabitants could never feel for any stranger the attachment and affection which they naturally entertain for the family of their Zemindar, and would have been afflicted if any other had been put over them. For this reason, the emperors, considering it as a means of conciliating the minds of the people, graciously fixed and confirmed the children of the deceased Zemindar in the office of their fathers and grandfathers, by issuing new Sunnuds to transfer the possession to them. By degrees Zemindaries became truly heritable property, which, however, could be transferred by gift or sale from one family to another. They could likewise be forfeited to the sovereign, by the Zemindar's deviating from his allegiance, neglecting to pay his tribute, or to discharge the duties of his station.

It is universally known, says Sir Charles Rouse Boughton, that, when the three provinces of Bengal, Bahar, and Orissa, were ceded to the British East India Company, the country was distributed among the Zemindars and Talookdars (see that article in this Vol.), who paid a stipulated revenue, by twelve instalments, to the sovereign power or its delegates. They assembled at the capital in the beginning of every Bengal year (commencing in April), in order to complete their final payments, and make up their annual accounts; to settle the discount to be charged upon their several remittances in various coins for the purpose of reducing them to one standard, or adjust their concerns with their bankers; to petition for remissions on account of storms, drought, inundation, disturbances, and such like; to make their representations of the state, and occurrences of their districts: after all which they entered upon the collections of the new year; of which, however, they were not permitted to begin receiving the rents from their own farmers, till they had completely closed the accounts of the preceding year, so that they might not encroach upon the new rents, to make up the deficiency of the past. Our author proves, we think completely, the right of the Zemindars to transfer their possessions, either by inheritance to their children, or, with the consent of the sovereign, to other families; and he argues strenuously and successfully against the bad policy, as well as injustice, of interfering with those rights, as long as the Zemindars discharge the duties of their several stations.

(A) This event took place towards the close of the 12th century. N. B. *Kheräje* signified specifically the tribute paid by a conquered country.

FINIS.

DIRECTIONS FOR PLACING THE PLATES.

PART I.

Plate XXX., XXXI., XXXII.	to face Page	82
XXXIII.		110
XXXIV., XXXV.		158
XXXVI., XXXVII.		262
XXXVIII., XXXIX.		312
XL., XLI.		380

PART II.

Plate XLII.	to face Page	530
XLIII., XLIV.		674
XLV.		732
XLVI.		742
XLVII.		766
XLVIII., XLIX., L.		812

Edinburgh:

PRINTED BY JOHN BROWN, ANCHOR CLOSE.

1803.